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JOURNAL OF GERONTOLOGY

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THE EXCRETION OF URINARY STEROIDS BY MEN AND WOMEN OF VARIOUS AGES

GREGORY PINCUS, D.Sc., LOUISE P. ROMANOFF, B.A., AND JAMES CARLO

(From the Worcester Foundation for Experimental Biology, Shrewsbury, Massachusetts)

A preliminary report has been made of androgen, 17-ketosteroid, and corticosteroid excretion in men and women of various age groups (24, 25). In this paper the final data of a survey which includes 297 male subjects and 320 female subjects are presented. In addition to the types of steroids mentioned above, we have conducted urinary assays for non-ketonic neutral steroid and for estrogens separated into estradiol, estrone, and estriol fractions.

MATERIAL AND METHODS

The 617 subjects of this study were volunteers recruited from the local community. They were healthy persons free from overt or ascertainable disease. No particular attempt was made to have the sample representative of the community as a whole, but men and women of all walks of life are in fact included. Urine collections from the premenopausal female subjects were generally taken at the 16th to 20th day of the menstrual cycle and in no instance were collections taken during the menstrual period itself.

The schedule of urine collections required of each subject complete collection of all voidings for 3 successive days. Three daily specimens were obtained for each 24-hour period: (a) a "waking" specimen covering the period from waking to 3 to 4 hours later, (b) a "day" specimen extending from the end of the waking period to the time of going to sleep, and (c) a "sleep" specimen including all voidings from the time of going to sleep to the time of waking. Within 24 hours of the final collection, steroid extraction was instituted. Toluol was present as a preservative in each specimen bottle.

The method of analyzing these urines was as follows: (a) an aliquot of each of the 9 diurnal specimens was hydrolyzed and extracted by methods previously described (18); (b) the neutral ketonic fractions were in every instance analyzed for 17-ketosteroid by the Zimmermann reaction and in practically every instance by the $SbCl_3$ reaction chiefly specific for saturated 17-ketosteroids as described by Pincus (17); (c) an analysis for $SbCl_3$ chromogenic steroid by the application of the Pincus reaction to the pooled 3-day non-ketonic fractions was undertaken with most, but not all, of the available samples; (d) the phenolic extracts of most of the hydrolyzed specimens were combined (representing approximately the 3-day collection total), separated into estradiol, estrone, and estriol fractions, and assayed by a modified Allen-Doisy procedure[1] (23); (e) aliquots of the pooled neutral ketonic extracts of a number of collections were assayed for androgenic activity using the method of inunction of the day-old chick comb against an androsterone standard[1] (18); (f) an aliquot of each of a single day's diurnal collection was analyzed for neutral reducing lipid by methods previously described (27).

The actual numbers of determinations of each of the steroid types are presented in the tables for each age group. Where less than

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This investigation has been aided by grants from the U. S. Public Health Service (G-736), the Damon Runyon Fund (DRI-61C), and Ciba Pharmaceutical Products, Inc.

[1] With the numbers of animals usually used a standard error of estimate of 30% was obtained in these assays.

the total population in each group is represented, no particular selection is involved. It was unfortunately not possible to conduct every type of determination for each individual represented; certain technical considerations (*e.g.*, the necessity for fresh urines for corticosteroid extraction; inadequate amounts of ketonic residues for accurate androgen assay in certain cases) as well as occasional losses in manipulation were largely responsible for the omissions. The data of the Zimmermann assays for each individual have been averaged to individual means before including them in the group means.

Results

In tables 1 and 2 are presented the mean steroid output values and their standard errors

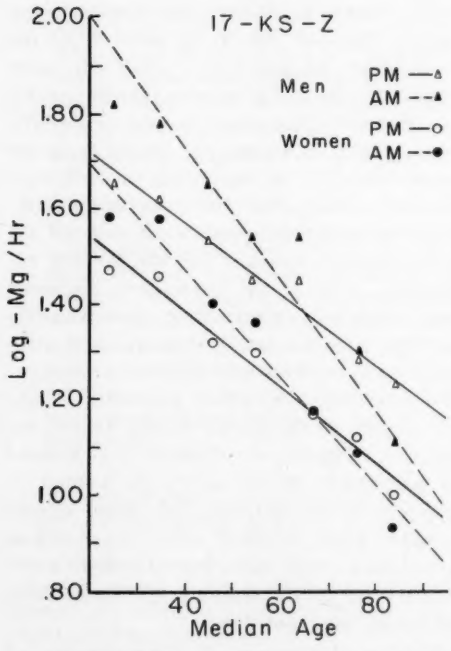

Fig. 1. The relationship between median age (abscissa) and the logarithm of the mean output (ordinate) of total 17-ketosteroids as measured by the Zimmermann reaction (17-KS-Z) in urine specimens collected from men and women during the period of sleep (P. M.), and the several hours following waking (A. M.) Data from tables 1 and 2.

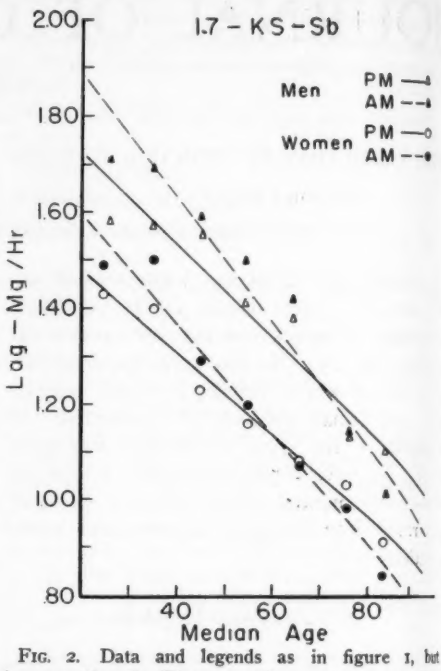

Fig. 2. Data and legends as in figure 1, but demonstrating the Pincus reaction measurements (17-KS-Sb) of 17-ketosteroids.

in the various age groups for men and women, respectively. Inspection of these tables at once suggests that certain types of substances measured (*e.g.*, the 17-ketosteroids) decrease markedly in the older age groups whereas others (*e.g.*, estrogens in the male subjects) are not notably different in persons of different ages. In order to assess the degree of change which may be reflective of increasing age, we have plotted the mean values for each age group, expressed them as a function of the median age, and calculated the constants of the equations which express the regression of output value on median age. Linear regressions for most of the measurements were obtained when the logarithms of the output values were plotted against median age. The various types of steroids are considered separately below:

17-Ketosteroids: In figure 1 the output: age relationship for urinary 17-ketosteroids as measured by the Zimmermann reaction is presented. The decline in output with increasing

TABLE 1. THE MEAN OUTPUT OF VARIOUS URINARY STEROIDS IN MALE SUBJECTS.

Age Range (Years)		17-Ketosteroids by Zimmermann Reaction Mg./Hr.		17-Ketosteroids by Pincus Reaction Mg./Hr.		Neutral Non-Ketonic Steroids Mg./Hr.		Neutral Reducing Lipids Mg./Hr.		Estrogen Rat Units/24 Hrs.		Androgen, Mg. Androsterone Equiv./Hr.
		Sleeping	Waking	Day	Sleeping	Waking	Day	Sleeping	Waking	Day	Estriol	Estradiol	Estrone	Total	
20-29	Number	52	52	52	48	46	46	25	26	25	27	27	27	33	33	34	32	19
	Mean	.472	.695	.524	.421	.558	.436	.291	.455	.324	1.76	2.52	2.19	5.21	3.67	2.50	11.50	0.1546
	Standard error	±.022	±.032	±.022	±.025	±.035	±.030	±.037	±.057	±.042	±.182	±.206	±.177	±0.54	±0.32	±0.36	±0.71	±0.0146
30-39	Number	53	53	52	47	47	47	26	26	25	25	26	26	25	25	25	25	19
	Mean	.434	.641	.458	.398	.575	.421	.268	.417	.312	1.79	2.66	2.02	5.31	3.88	3.24	12.44	0.1166
	Standard error	±.017	±.031	±.021	±.022	±.048	±.026	±.022	±.037	±.027	±.175	±.195	±.135	±0.74	±0.38	±0.50	±1.31	±0.0168
40-49	Number	40	40	40	38	37	38	31	28	28	20	19	20	22	22	22	22	16
	Mean	.359	.481	.430	.372	.418	.313	.291	.428	.276	2.27	2.69	2.57	5.93	3.44	2.66	12.01	0.0607
	Standard error	±.019	±.032	±.023	±.021	±.032	±.018	±.024	±.046	±.019	±.089	±.144	±.161	±0.79	±0.35	±0.32	±1.04	±0.0110
50-59	Number	43	44	44	42	43	42	33	33	33	21	20	21	20	20	20	20	15
	Mean	.301	.372	.328	.278	.341	.248	.231	.318	.194	1.87	2.20	2.23	5.84	2.51	2.46	10.64	0.0603
	Standard error	±.016	±.020	±.017	±.016	±.021	±.017	±.029	±.033	±.013	±.139	±.177	±.210	±0.46	±0.43	±0.44	±0.84	±0.0132
60-69	Number	36	36	36	34	34	34	25	26	26	21	20	21	15	15	15	15	15
	Mean	.299	.392	.318	.259	.293	.264	.199	.317	.205	2.12	2.48	2.13	4.69	2.99	1.95	9.61	0.0580
	Standard error	±.018	±.030	±.019	±.017	±.021	±.016	±.016	±.039	±.026	±.144	±.242	±.176	±0.67	±0.59	±0.47	±1.25	±0.0116
70-79	Number	42	42	42	38	40	40	30	30	29	20	20	20	18	18	17	17	16
	Mean	.210	.230	.222	.163	.183	.168	.185	.287	.178	1.72	1.92	1.87	7.70	2.61	1.95	12.48	0.0657
	Standard error	±.015	±.019	±.014	±.022	±.025	±.011	±.016	±.034	±.017	±.148	±.243	±.155	±1.57	±0.45	±0.55	±1.35	±0.0099
80-89	Number	30	30	30	28	30	30	23	22	22	17	17	17	13	13	13	13	14
	Mean	.184	.152	.181	.135	.153	.142	.243	.306	.201	1.83	1.94	1.93	6.88	2.08	1.53	10.48	0.0218
	Standard error	±.015	±.016	±.013	±.009	±.025	±.011	±.011	±.011	±.008	±.229	±.252	±.229	±2.09	±0.49	±0.34	±2.39	±0.0039

TABLE 2. THE MEAN OUTPUT OF VARIOUS URINARY STEROIDS IN FEMALE SUBJECTS.

Age Range (Years)		17-Ketosteroids by Zimmermann Reaction Mg./Hr.			17-Ketosteroids by Pincus Reaction Mg./Hr.			Neutral Non-Ketonic Steroids Mg./Hr.			Neutral Reducing Lipids Mg./Hr.			Estrogen Rat Units/24 Hrs.			Androgen, Mg. Androsterone Equiv./Hr.
		Sleeping	Waking	Day	Sleeping	Waking	Day	Sleeping	Waking	Day	Sleeping	Waking	Day	Estriol	Estradiol	Estrone	Total	
20-29	Number	47	46	47	47	46	47	34	34	34	21	21	21	21	27	27	25	16
	Mean	.313	.413	.363	.294	.354	.303	.265	.504	.262	1.61	2.22	1.88	16.60	9.57	6.11	33.62	0.0817
	Standard error	±.016	±.026	±.017	±.019	±.031	±.018	±.023	±.020	±.022	±.081	±.182	±.166	±2.83	±1.60	±1.22	±5.02	±0.0200
30-39	Number	41	40	41	40	40	40	34	35	35	20	20	20	21	21	21	21	12
	Mean	.312	.418	.355	.271	.348	.310	.274	.520	.287	1.60	1.86	2.07	19.45	10.15	4.79	34.39	0.0534
	Standard error	±.021	±.033	±.018	±.016	±.026	±.018	±.026	±.048	±.026	±.113	±.164	±.203	±3.40	±2.15	±.81	±5.49	±0.0139
40-49	Number	41	41	41	41	41	41	35	33	33	20	21	21	17	17	17	17	12
	Mean	.225	.284	.270	.190	.232	.204	.208	.291	.198	1.34	1.77	2.04	11.25	4.69	2.81	18.75	0.0193
	Standard error	±.013	±.022	±.014	±.014	±.020	±.015	±.016	±.026	±.020	±.093	±.144	±.214	±2.79	±0.79	±0.51	±3.36	±0.0053
50-59	Number	45	44	45	45	44	45	35	35	35	22	21	21	18	17	18	17	12
	Mean	.214	.269	.234	.166	.197	.184	.202	.265	.177	1.67	1.81	1.72	4.94	3.65	2.24	10.73	0.0168
	Standard error	±.013	±.023	±.013	±.014	±.021	±.014	±.020	±.026	±.012	±.141	±.158	±.120	±1.10	±0.84	±0.51	±1.97	±0.0031
60-69	Number	27	27	27	26	26	26	20	17	18	18	17	17	18	18	18	18	9
	Mean	.159	.172	.189	.136	.147	.130	.150	.192	.144	1.35	1.39	1.73	2.04	2.33	2.26	6.64	0.0124
	Standard error	±.012	±.018	±.011	±.013	±.021	±.011	±.019	±.023	±.024	±.147	±.156	±.198	±0.56	±0.57	±0.52	±1.47	±0.0021
70-79	Number	67	66	66	65	62	64	29	28	27	26	26	26	47	47	47	47	4
	Mean	.150	.153	.174	.124	.122	.134	.161	.204	.154	1.60	1.69	1.89	2.95	2.23	1.97	7.16	0.0105
	Standard error	±.009	±.012	±.010	±.009	±.011	±.010	±.019	±.020	±.015	±.161	±.160	±.168	±0.39	±0.34	±0.29	±0.74	±0.0021
80-99	Number	52	52	51	51	48	51	22	20	21	22	20	22	42	42	42	42	12
	Mean	.113	.098	.121	.092	.083	.089	.145	.173	.120	1.50	1.51	1.57	3.27	1.90	1.60	6.88	0.0133
	Standard error	±.008	±.008	±.008	±.008	±.007	±.007	±.014	±.020	±.015	±.140	±.113	±.163	±0.47	±0.33	±0.30	±0.75	±0.0042

age is obvious in the data for both men and women and occurs regardless of the time of the urine collection. The rate of change with age is, however, clearly less in the sleep (p.m.) specimens than in the waking (a.m.) specimens. For each comparable age group the women, on the average, excrete significantly less than the men as indicated by the vertical separations of the regression lines.

In figure 2 a similar graphic representation is made of the 17-ketosteroids as measured by the Pincus reaction. Again, the lower slope of the sleep values is evident as well as the separation of the data for the sexes.

The rate of output change with age is best expressed by the value of the slope constant (b) of the regression equations. These slope constant values for the various 17-ketosteroid measurements are presented in table 3. In both sexes for each of the two types of reaction used, the maximal value of b is had for the data of the waking (a.m.) specimens, and in each of the 4 sets of tabulations this waking specimen value of b is significantly higher than the sleep (p.m.) or day specimen values. The b value of the sleep specimens is least in all except the Pincus reaction measurements of the men's data, but in these instances the sleep value of b is not significantly less than the day value of b; however, the sleep b value of the Pincus reaction data for the men is significantly higher than the day value. Again, except for the Pincus reaction day values, the values of b are not significantly different between the sexes in comparable types of measurements.

TABLE 3. VALUES OF THE SLOPE CONSTANT, b, FOR THE REGRESSION OF 17-KETOSTEROID OUTPUT ON AGE.

17-Ketosteroids	Male Subjects		Female Subjects	
Zimmermann Reaction	b	Standard Error	b	Standard Error
Sleeping	—.0075	± .0005	—.0080	± .0007
Waking	—.0118	± .0012	—.0113	± .0010
Day	—.0081	± .0006	—.0084	± .0008
17-Ketosteroids Pincus Reaction				
Sleeping	—.0096	± .0014	—.0087	± .0005
Waking	—.0129	± .0016	—.0114	± .0008
Day	—.0052	± .0011	—.0095	± .0009

In considering the implications of these findings it is noted first of all that a constant output decline with increasing age is suggested, although in each sex the actual mean values for the third and fourth decades are quite similar (tables 1 and 2 and figs. 1 and 2). Secondly, in both sexes, significantly elevated b values for the waking specimens suggest that the effect of age on 17-ketosteroid output is most marked during the hours immediately following sleep. The significance of this will be discussed in connection with changes in the diurnal rhythm with age. Finally, the general lack of sex difference in b values suggests that the difference between the sexes inheres only in a constant higher output by men at all ages, the rate of change with age being entirely similar.

Non-ketonic steroids: In figure 3 the data for non-ketonic steroid output are plotted

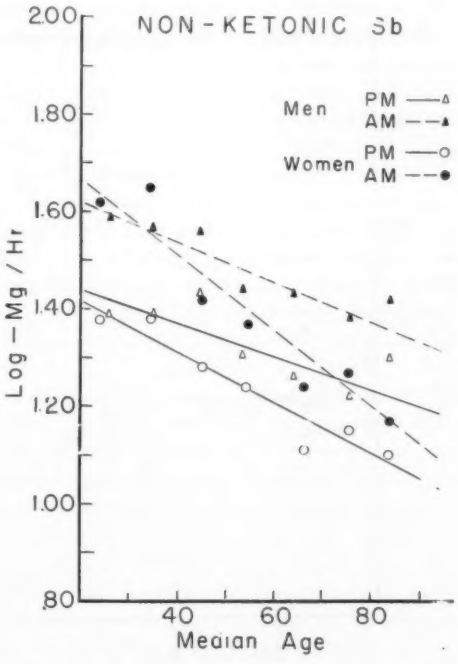

FIG. 3. Data and legends as in figure 1, but demonstrating the measurements of neutral non-ketonic steroid.

against median age in the two sexes. Here again the output decline with age and a somewhat steeper slope for the waking values are obvious. The output difference between the sexes is, however, most obvious in the later decades. The slope constants for the regression of output on median age are presented in table 4. As with 17-ketosteroid data, the sleep

TABLE 4. VALUES OF THE SLOPE CONSTANT, b, FOR THE REGRESSION OF NON-KETONIC NEUTRAL STEROID OUTPUT ON AGE.

	Male Subjects		Female Subjects	
Period	b	Standard Error	b	Standard Error
Sleeping	—.0031	± .0010	—.0052	± .0007
Waking	—.0040	± .0007	—.0079	± .0011
Day	—.0046	± .0008	—.0061	± .0010

values of b are the lowest, but only in the women's data is the waking value significantly higher than the sleep value, and in the men's data b is not significantly different in either sleep, waking, or day values. It should be noted that the b values for the women's data exceed those of the men's data, but significantly so only in the waking values. The implication is that the effect of age on non-ketonic steroid output is more marked in the women than in the men.

Neutral reducing lipids: The data of figure 4 demonstrate no obvious change with age in the sleep output of neutral reducing lipid and a rather slow decline in the waking values. The sex difference in absolute output is again indicated. Inspection of table 5 indicates a

TABLE 5. VALUES OF THE SLOPE CONSTANT, b, FOR THE REGRESSION OF NEUTRAL REDUCING LIPID OUTPUT ON AGE.

	Male Subjects		Female Subjects	
Period	b	Standard Error	b	Standard Error
Sleeping	+.0002	± .0013	—.0009	± .0007
Waking	—.0030	± .0010	—.0024	± .0008
Day	—.0004	± .0013	—.0020	± .0006

significant value of b for the waking values of both sexes and no significant slope for the sleep values and the day values of the male

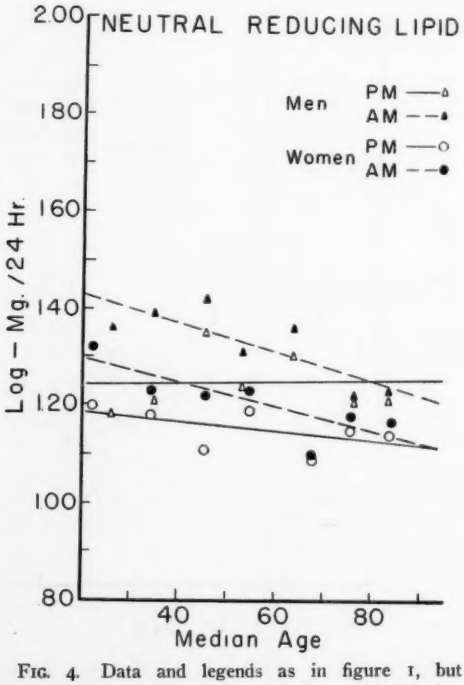

FIG. 4. Data and legends as in figure 1, but demonstrating the measurements of neutral reducing lipids.

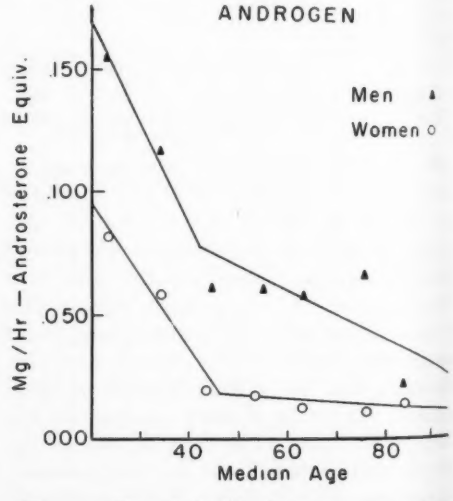

FIG. 5. The relationship between mean urinary ketonic androgen output and median age. Data from tables 1 and 2.

subjects. There is no significant difference in b values between the sexes at comparable collection times. The implication is that neutral reducing lipid output is not very markedly affected by age in either sex.

Androgens: Mean androgen excretion data are plotted in figure 5. Here a change is seen in the rate of output decline in both sexes beginning in the fifth decade, with the rate of decline throughout being much greater in the male subjects. With the exception of the ninth decade, the absolute output in the males is consistently higher than in the females.

Estrogens: The total estrogen output values are plotted against age in figure 6. A dissimilarity between the sexes is again evident,

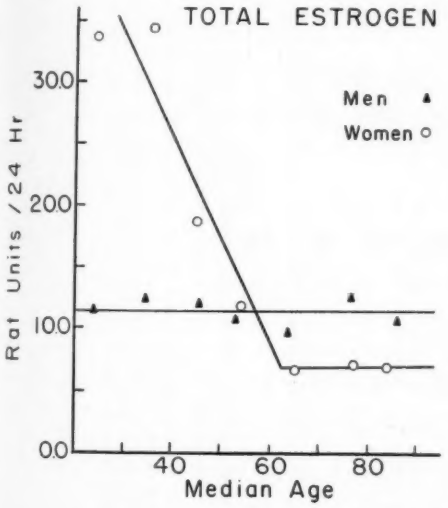

FIG. 6. Total urinary estrogen, as rat units per 24 hours, plotted as a function of median age. Data from tables 1 and 2.

the men's data indicating no output shift with age whereas the women's data show a decline to the seventh decade with constant output thereafter. Estrogen output is presumably notably affected by age in women, particularly after the fourth decade, but is not particularly reflective of aging after the seventh decade.

In figure 7 the output values for the 3 naturally-occurring estrogens are plotted against age. The data for the male subjects suggests an increase in estriol output and a decrease in estradiol and estrone excretion with age. The

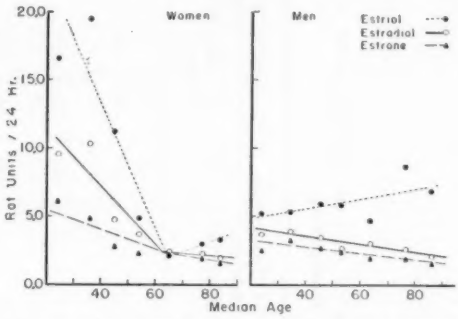

FIG. 7. Variations in mean output of the separated urinary estrogens (estriol, estradiol, and estrone) with age in men (graphs at right) and women (graphs at left). Data from tables 1 and 2.

latter two decreases seem to be significant, the former increase scarcely so. The data for the individual estrogens of the female subjects generally tend to parallel the total estrogen output change with age (fig. 6), but there is the suggestion of a secondary rise in estriol output in older subjects, along with slight declines in estrone and estradiol excretion.

The estrogen output data considered generally imply that a decrement with aging in women is reflected up to a point but that in men the estrogen output is very nearly independent of age. The significance of the data on the separated estrogens will be discussed later.

Diurnal rhythm in neutral steroid excretion.—We have previously demonstrated (16, 26) a diurnal rhythm in the excretion of 17-ketosteroids and neutral reducing lipids; this involved a maximal output during the hours immediately following waking, a decline thereafter, and a minimal output during sleep. In seeking the simplest method for expressing these diurnal changes in the various age groups of our population, we have employed the difference between the logarithm of the sleep value and the logarithm of the waking and day values, respectively.

TABLE 6. DIURNAL CHANGES IN STEROID EXCRETION BY MALE SUBJECTS EXPRESSED AS THE DIFFERENCE BETWEEN THE LOGARITHM OF THE SLEEP OUTPUT AND THE LOGARITHMS OF THE WAKING AND DAY OUTPUTS, RESPECTIVELY.

Age Range (Years)		17-Ketosteroids by Zimmermann Reaction Mg./Hr.		17-Ketosteroids by Pincus Reaction Mg./Hr.		Neutral Non-Ketonic Steroids Mg./Hr.		Neutral Reducing Lipids Mg./24 Hrs.	
		Waking	Day	Waking	Day	Waking	Day	Waking	Day
20-29	Number	52	52	46	46	24	23	27	27
	Mean ± Standard Error	.17 ± .014	.05 ± .020	.12 ± .033	—.01 ± .036	.22 ± .052	.03 ± .049	.18 ± .044	.12 ± .042
30-39	Number	53	53	47	47	26	25	24	24
	Mean ± Standard Error	.16 ± .017	.01 ± .019	.12 ± .033	.02 ± .033	.18 ± .047	.05 ± .041	.18 ± .030	.07 ± .023
40-49	Number	40	40	36	37	28	28	19	19
	Mean ± Standard Error	.12 ± .023	.08 ± .021	.04 ± .027	—.07 ± .032	.13 ± .042	—.03 ± .029	.06 ± .020	.05 ± .030
50-59	Number	44	44	42	41	33	33	20	20
	Mean ± Standard Error	.09 ± .024	.05 ± .023	.08 ± .028	—.05 ± .026	.13 ± .034	—.05 ± .030	.07 ± .036	.06 ± .036
60-69	Number	36	36	34	34	25	25	20	20
	Mean ± Standard Error	.10 ± .037	.03 ± .025	.03 ± .041	.01 ± .029	.17 ± .054	—.01 ± .028	.05 ± .037	—.03 ± .045
70-79	Number	42	42	38	38	30	29	20	20
	Mean ± Standard Error	.02 ± .035	.03 ± .021	.003 ± .051	.05 ± .032	.16 ± .029	—.02 ± .042	.02 ± .060	.04 ± .045
80-99	Number	30	30	28	29	22	22	17	17
	Mean ± Standard Error	—.12 ± .046	—.001 ± .026	—.06 ± .075	.01 ± .038	.11 ± .056	—.09 ± .054	.02 ± .053	.03 ± .036

= = Significant difference from the sleep value, $p < .001$.
— = Significant difference from the sleep value, $p < .01$.
--- = Significant difference from the sleep value, $p < .02$.
..... = Significant difference from the sleep value, $p < .05$.

TABLE 7. DIURNAL CHANGES IN STEROID EXCRETION BY FEMALE SUBJECTS EXPRESSED AS THE DIFFERENCE BETWEEN THE LOGARITHM OF THE SLEEP OUTPUT AND THE LOGARITHMS OF THE WAKING AND DAY OUTPUTS, RESPECTIVELY.

Age Range (Years)		17-Ketosteroids by Zimmermann Reaction Mg./Hr.		17-Ketosteroids by Pincus Reaction Mg./Hr.		Neutral Non-Ketonic Steroids Mg./Hr.		Neutral Reducing Lipids Mg./24 Hrs.	
		Waking	Day	Waking	Day	Waking	Day	Waking	Day
20-29	Number	46	46	46	47	34	34	21	21
	Mean ± Standard Error	.11 ± .018	.07 ± .019	.06 ± .028	.01 ± .022	.25 ± .042	—.01 ± .033	.13 ± .041	.05 ± .028
30-39	Number	40	41	39	39	34	34	20	20
	Mean ± Standard Error	.12 ± .022	.07 ± .018	.10 ± .023	.06 ± .025	.26 ± .035	.03 ± .034	.04 ± .036	.10 ± .031
40-49	Number	41	41	41	41	33	33	20	20
	Mean ± Standard Error	.08 ± .024	.09 ± .017	.06 ± .033	.03 ± .025	.13 ± .034	—.03 ± .035	.12 ± .032	.16 ± .039
50-59	Number	44	45	44	45	34	34	21	21
	Mean ± Standard Error	.06 ± .031	.04 ± .020	.05 ± .035	.05 ± .033	.11 ± .037	—.05 ± .037	.04 ± .033	.03 ± .043
60-69	Number	27	27	27	27	16	17	18	18
	Mean ± Standard Error	.01 ± .055	.03 ± .043	—.02 ± .068	—.02 ± .023	.17 ± .065	—.03 ± .053	.05 ± .068	.14 ± .042
70-79	Number	66	66	62	64	28	27	26	26
	Mean ± Standard Error	—.04 ± .028	.07 ± .017	—.04 ± .037	.01 ± .023	.11 ± .050	—.02 ± .035	.03 ± .043	.09 ± .028
80-99	Number	52	51	48	51	20	21	20	20
	Mean ± Standard Error	—.07 ± .033	.01 ± .023	—.08 ± .034	—.01 ± .025	.09 ± .050	—.12 ± .062	.05 ± .030	.01 ± .042

= = Significant difference from the sleep value, $p < .001$.
— = Significant difference from the sleep value, $p < .01$.
--- = Significant difference from the sleep value, $p < .02$.
..... = Significant difference from the sleep value, $p < .05$.

In tables 6 and 7 the mean differences in the various age groups of men and women are presented. The significance of the differences between the sleep and the other values was determined by the t test, and the levels of significance are indicated in the tables. Significant output increase over the sleep values is seen in at least one of the waking or day values for every type of neutral steroid in the third and fourth decades in both men and women. The data for the fifth decade exhibit similar significant elevated output in 17-ketosteroids, as measured by the Zimmermann reaction, in non-ketonic steroids and in neutral reducing lipids, but not in 17-ketosteroids as measured by the Pincus reaction. In fact among the male subjects there is a marginally significant decline in the day values. In the succeeding decades, these diurnal increases tend to disappear except in the waking values of the non-ketonic steroids in both sexes and the day values of neutral reducing lipids in the women. A tendency for the reversal of the diurnal rhythm is suggested by negative values of 17-ketosteroid output differences, which negative values are statistically significant in the ninth decade.

Thus an over-all tendency for the diurnal rhythm to disappear with age is observed. Its disappearance is first evidenced in the data for 17-ketosteroids measured by the Pincus reaction, second in the Zimmermann ketosteroid titers, third in the neutral reducing lipid data. A notable sustainment of the waking value increase is seen in the non-ketonic steroid data. The effect of age would seem to involve an abolishment of those factors tending to sustain the diurnal rhythm. We have previously reported evidence that the 17-ketosteroid increase seems to be a function of daily activity (19). One might deduce, therefore, that we are observing here a reduction of activity in elderly persons, or even in the eldest a greater activity during sleep than in the waking hours. But clearly it cannot be so simple. The fact is that for different classes of steroids the abolishment of the diurnal rhythm advances at quite different rates, and even if it be true that daily activities evoke different types of output increase for each class of steroid, the basis for such differential evocation remains to be elucidated.

Variability.—There are two aspects of variability of our data which merit some inquiry. The first is the question of individual variability in any given age group and the second is the group variability from age to age.

We have considered the first aspect by comparing within-man and between-man variances for 17-ketosteroid output. Fortunately this is possible since most of our subjects collected 3 diurnal specimens on 3 different days and the Zimmermann titer of 17-ketosteroids was determined for each specimen. In setting up the variance analysis for various types of specimens and various age groups we have used only the data for those individuals contributing 3 urine specimens each and have arbitrarily selected for analysis young, middle-aged, and elderly groups. The data are presented in table 8. A significant value of the variance ratio, F, is seen for each set of data except the waking output values of the oldest men. The implication of this analysis is that within any age group each individual has a characteristic 17-ketosteroid output and that much the largest contribution to the variability within any age group is made by the differences between individuals. Certain individuals are consistently "high" excretors, other consistently "low" excretors.

In tables 9 and 10 are presented the standard deviations and the coefficients of variation for the various steroid excretion data in men and women, respectively. Fairly regular relationships to age are displayed by the values of σ in the data for 17-ketosteroid output as measured either by the Zimmermann or Pincus reactions in both sexes. These are illustrated in figures 8 and 9 which demonstrate: (a) a relatively rapid decline with age of the σ values for the waking outputs, (b) a slower decline with age of the σ values for the sleep and day outputs which are not notably distinguishable one from the other, and (c) the tendency for the waking output data σ values to exceed

the sleep and day output σ values at all ages but particularly in the younger decades. Similar but somewhat less regular trends are exhibited by the σ values for the non-ketonic steroid data (fig. 10). The same data for the neutral reducing lipids, in contrast, exhibit no definable change with age but seem to scatter pretty much at random. The relationship of σ to age does not seem to differ notably between the sexes although the σ values for the women subjects tend, at any given age, to be somewhat lower than those for the men. The σ's of the estrogen output data do show differences in the two sexes (fig. 11): (a) a sharp decline with age in the female subjects' data and (b) larger absolute values of the σ's in the early decades for the women and a tendency for overlapping in the latter decades.

While the decline with age in σ values of some of these data demonstrates a tendency for reduced scatter of values about the mean, the relative variation, as expressed by the coefficient of variation does not seem to decline with age (tables 9 and 10). The variations with age are rather irregular, but there is either no obvious tendency for change with age or the suggestion of an irregular increase in the later decades (cf., 17-ketosteroid coefficients of variation). It should be noted, however, that the coefficients of variation for the waking outputs of 17-ketosteroid rather uniformly exceed the corresponding sleep output values in the various age groups. This seems to hold also for most of the male subjects' data on non-ketonic steroid and neutral reducing lipid outputs and of the female subjects' neutral reduc-

TABLE 8. A COMPARISON OF WITHIN-MAN AND BETWEEN-MAN VARIANCES IN URINARY 17-KETOSTEROID (ZIMMERMANN) OUTPUT VALUES.

Subjects	Age Range (Years)	Specimen	d. f. Between	d. f. Within	Variance Ratio, F
Men	20-29	Sleep	38	78	3.38
	40-49	"	33	68	2.65
	70-79	"	25	52	3.83
	80-89	"	18	38	5.07
	20-29	Waking	34	70	3.14
	70-79	"	27	56	2.98
	80-89	"	11	24	1.67
	20-29	Day	31	64	2.63
Women	20-29	Sleep	34	70	8.22
	40-49	"	35	72	5.52
	70-79	"	43	88	3.00
	80-99	"	38	78	8.14
	20-29	Waking	30	62	10.91
	80-99	"	16	34	3.31
	20-29	Day	32	66	7.60
	80-99	"	32	66	5.03

$=\!=$ = Significant, $p < 0.001$.
$-\!-$ = Significant, $p < 0.01$.

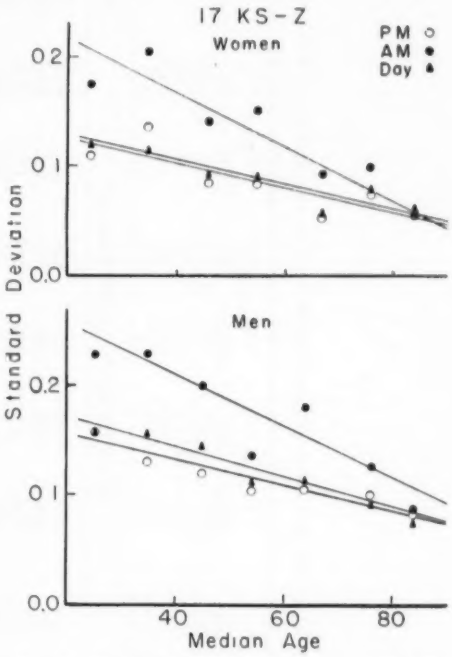

FIG. 8. The standard deviations (σ) of the Zimmermann reaction values (17-KS-Z) for urinary 17-ketosteroids in the sleep (P. M.), waking (A. M.) and day specimens of the various age groups of men (lower graph) and women (upper graph) plotted against the median age. Data from tables 9 and 10.

TABLE 9. THE STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION OF VARIOUS MEASUREMENTS OF URINARY STEROID IN MALE SUBJECTS.

Age Range (Years)	Sleep Sigma	Sleep Coefficient of Variation	Waking Sigma	Waking Coefficient of Variation	Day Sigma	Day Coefficient of Variation	Sleep Sigma	Sleep Coefficient of Variation	Waking Sigma	Waking Coefficient of Variation	Day Sigma	Day Coefficient of Variation	24-Hour Sigma	24-Hour Coefficient of Variation
	17-Ketosteroids by Zimmermann Reaction						17-Ketosteroids by Pincus Reaction						Total Estrogens	
20-29	.157	32.3	.229	33.0	.157	30.0	.173	40.9	.237	42.4	.203	46.5	4.02	35.0
30-39	.130	30.0	.229	35.7	.155	33.8	.151	37.9	.329	57.2	.178	42.4	6.55	54.5
40-49	.119	33.1	.200	41.6	.143	33.3	.129	34.7	.195	46.7	.111	35.4	3.76	35.2
50-59	.103	34.2	.135	36.3	.111	33.9	.104	37.4	.138	40.4	.110	44.4	3.76	35.3
60-69	.105	35.1	.180	45.9	.112	35.2	.099	38.2	.122	41.7	.093	35.3	4.83	50.3
70-79	.100	47.6	.125	54.4	.091	41.0	.131	80.3	.158	86.3	.070	41.4	6.50	50.5
80-89	.081	44.0	.086	56.6	.073	40.4	.049	36.3	.132	97.8	.060	42.5	8.62	82.3
	Neutral Non-Ketonic Steroids						Neutral Reducing Lipids							
20-29	.185	63.6	.291	64.0	.210	64.9	.947	53.8	1.070	42.5	.919	41.9		
30-39	.112	41.9	.189	45.2	.135	43.4	.877	49.0	.976	36.7	.690	34.1		
40-49	.134	44.6	.244	56.9	.100	36.4	.392	17.3	.626	23.3	.720	28.0		
50-59	.167	72.1	.190	59.6	.075	38.4	.635	34.0	.791	36.0	.961	43.1		
60-69	.080	40.1	.199	62.8	.132	64.6	.660	31.1	1.080	43.5	.807	37.9		
70-79	.088	47.4	.186	64.9	.092	51.5	.664	38.6	1.090	56.8	.695	37.2		
80-89	.053	21.7	.052	16.9	.038	18.7	.945	51.6	1.040	53.7	.945	48.7		

TABLE 10. THE STANDARD DEVIATIONS AND COEFFICIENTS OF VARIATION OF VARIOUS MEASUREMENTS OF URINARY STEROID IN FEMALE SUBJECTS.

Age Range (Years)	Sleep		Waking		Day		Sleep		Waking		Day		24-Hour	
	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation	Sigma	Coefficient of Variation
	17-Ketosteroids by Zimmermann Reaction						17-Ketosteroids by Pincus Reaction						Total Estrogens	
20-29	.110	35.2	.176	42.6	.119	32.8	.130	44.2	.210	59.4	.124	40.8	25.1	74.6
30-39	.136	43.6	.206	49.3	.114	32.1	.101	37.2	.164	47.2	.114	36.7	25.3	82.7
40-49	.085	37.8	.142	50.0	.092	34.0	.090	47.2	.128	55.2	.096	47.0	14.8	79.1
50-59	.084	39.3	.152	56.6	.090	38.5	.094	56.5	.139	70.7	.094	51.0	8.12	75.6
60-69	.052	32.7	.094	54.6	.055	29.2	.067	49.5	.107	72.9	.056	43.1	6.23	93.8
70-79	.074	49.3	.100	65.4	.078	44.9	.072	58.5	.086	70.9	.080	59.7	5.07	70.9
80-99	.057	55.4	.055	56.2	.058	47.9	.057	62.0	.049	58.4	.050	56.2	4.86	70.6
	Neutral Non-Ketonic Steroids						Neutral Reducing Lipids							
20-29	.134	50.6	.117	23.2	.128	49.0	.373	23.2	.835	37.6	.760	40.4		
30-39	.152	55.3	.284	54.7	.154	53.7	.503	31.4	.732	39.4	.909	43.9		
40-49	.095	45.5	.149	51.4	.115	58.0	.415	31.0	.658	37.2	.980	48.0		
50-59	.118	58.7	.154	57.9	.071	40.3	.661	39.6	.724	40.0	.551	32.0		
60-69	.085	56.6	.095	49.3	.102	70.8	.626	46.4	.642	46.2	.815	47.1		
70-79	.102	63.7	.106	51.9	.078	50.6	.822	50.7	.814	48.2	.854	45.2		
80-99	.066	45.2	.089	51.6	.069	57.3	.658	43.9	.506	33.5	.764	48.6		

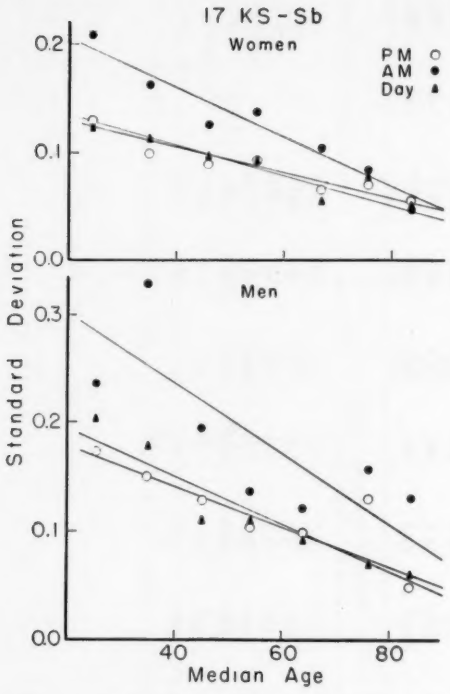

FIG. 9. Data and legends as in figure 8 but demonstrating the standard deviation data of the Pincus reaction measurements (17-KS-Sb) for neutral 17-ketosteroids.

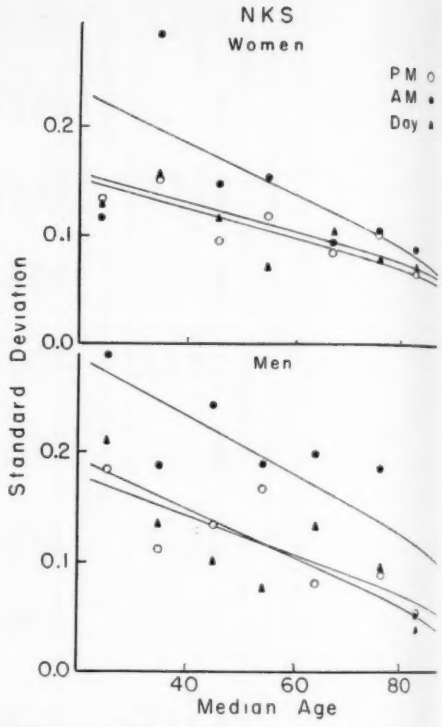

FIG. 10. Data and legends as in figure 8 but demonstrating the standard deviation data of the measurements of neutral non-ketonic steroids.

ing lipid data but not for their non-ketonic steroid data. In the case of the total estrogen output the women's data have, except for the last decade, larger coefficients of variation than the men's data.

DISCUSSION

Neutral steroids.—Perhaps the outstanding feature of our data is the difference in rate of change with age of the output of the various types of urinary steroids. In the case of those 3 classes of substances in which the data for men and women generally parallel each other, namely the 17-ketosteroids, the non-ketonic steroids, and the neutral reducing lipids, we observe marked, intermediate, and little or no output decline with age, respectively. It is pertinent to inquire concerning the origin and

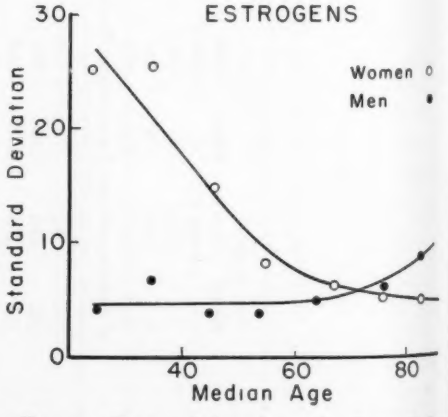

FIG. 11. Data and legends as in figure 8 but demonstrating the standard deviation data of the total estrogen output.

secretory precursors of these substances.

The neutral reducing lipids as measured represent adrenocortical steroids and their metabolites (9, 27). A certain moiety of the neutral reducing lipid in urine may be non-steroidal (10). If this moiety increases with age then the steroids contributing to the neutral reducing lipid titer decrease with age; conversely a differential decrease of this moiety with age would result in a net increase of the steroidal components. Since we cannot estimate this nonspecific substance we must take the data as they stand and deduce a constant rate of production by the adrenal cortex at all ages of neutral reducing lipid precursors during the sleep and day periods with a slight waning with age of the waking secretory rate. It is as if these substances are concerned with certain processes that *must* be sustained. Total adrenalectomy in man will lead to death unless replacement therapy with cortisone or hydrocortisone is practiced (11, 12, 13), and perhaps optimal sustainment is obtained with the addition of an electrolyte-regulating corticosteroid such as desoxycorticosterone (12, 13). The average basal neutral reducing lipid output may therefore represent the corticosteroids of this type produced at the rate needed for life sustainment. These types of substances are secreted in increasing amount under stress (15, 22), and, as we have previously suggested (19) the diurnal rise observed in the younger subjects represents the stress response of waking and starting the day's activities.

The chemical nature and the secretory precursors of the non-ketonic neutral steroid as we have measured them are rather obscure. Androstenediol, etiocholanediol, and pregnanediol are urinary constituents which would contribute to the colorimetric titers obtained, and these substances may originate from both gonadal and adrenocortical precursors. The sharp increase observed in waking specimens may be taken as a stress response and suggests a considerable adrenal contribution. Since cortisone administration inhibits the output of these substances (26), presumably by inhibiting pituitary ACTH secretion, an adrenal precursor is indicated, but it is probably not cortisone-like. The decline in output with age therefore may reflect the diminishing secretion of gonadal precursor(s) with no diminishment in adrenocortical precursor(s) or both adrenal and gonadal precursor(s) may fall off in time. If adrenal precursor(s) contributes to the urinary substance it must be precursor(s) different from those contributing to the neutral reducing lipid titer, since the rate of change of the latter with age differs significantly from that of the former (see above).

The chemical nature of the urinary 17-ketosteroids is well known and the mixture includes in men metabolites of both testicular and adrenocortical steroids and in women chiefly, if not exclusively, metabolites of adrenocortical steroids (5, 14). Androsterone and etiocholanolone, which between them account for 50 per cent to 70 per cent of both the Zimmermann and Pincus reaction chromogen, may originate from both testis and adrenal precursors whereas the 11-oxygenated urinary ketosteroids and dehydroepiandrosterone (and derivatives) seem to derive from adrenal precursors only; the latter reacts feebly with the Pincus reagent and the former not at all (17, 21). Were the decline with age observed only with male subjects, or if the rate of decline with age were very much more rapid in men, we might attribute the 17-ketosteroid decline to diminishment of testis precursor; but neither is true—in fact the slope constants of the regression of 17-ketosteroids on age do not differ significantly in the two sexes (table 3). It would therefore seem that the gonad precursors of the 17-ketosteroids contribute only in limited amount to the total 17-ketosteroid titer. This is borne out in part by the finding that eunuchs may excrete considerable 17-ketosteroid (2, 5), and it has been generally estimated that in men gonad hormone metabolites contribute 10 per cent to 30 per cent of the total 17-ketosteroids (5, 8). If, then, the 17-ketosteroid titer largely reflects adrenocortical precursors, then the 17-ketosteroid data are in marked contrast to those for neutral reducing lipid.

An estimate of certain adrenocortical hor-

mone metabolites may be had by taking the difference between the Zimmermann titer and the Pincus reaction titer. This difference should be proportional to the amount of 11-oxygenated ketosteroid plus a fraction of the dehydroepiandrosterone and its derivatives. The data on Zimmermann and Pincus reaction values in tables 1 and 2 are not derived from identical assemblies of subjects in each age group. Nonetheless, we have taken the differences between the mean values given and averaged them for 3 age ranges in table 11.

TABLE 11. THE MEAN DIFFERENCE BETWEEN MEAN ZIMMERMANN REACTION VALUES AND MEAN PINCUS REACTION VALUES FOR URINARY KETOSTEROIDS IN 3 AGE GROUPS.

	Zimmermann — Pincus Mg. per Hr.					
	Male Subjects			Female Subjects		
Age Range (Years)	Sleep	Waking	Day	Sleep	Waking	Day
20-49	0.024	0.089	0.047	0.032	0.060	0.057
50-69	0.032	0.065	0.067	0.034	0.049	0.060
70-99	0.048	0.023	0.047	0.024	0.023	0.036

The data assembled in this manner differ notably from the data for total 17-ketosteroids. In fact, they are rather remarkably similar to the data for neutral reducing lipid output, namely no clear decline of output with age in the sleep values (even a tendency for a rise in the data for male subjects), a regular decline with age in the waking values in both sexes, and little or no decline with age (except possibly in the eldest female subjects) in the day values. It would seem then that those substances contributing to the neutral reducing lipid titer act very much like those which react with the Zimmermann reagent but not with the Pincus reagent. It is very likely that at least the 11-oxygenated ketosteroids involved have as their precursors certain 11-oxygenated corticosteroids included in the measurements of neutral reducing lipid (3, 6).

We have pointed out that the urinary 17-ketosteroids of women seem to derive practically exclusively from adrenal precursors. This is based on the finding that the 17-ketosteroid titer does not significantly decline following ovariectomy (2, 5). It would seem to follow, therefore, that if one took the difference between the 17-ketosteroid titers of men and women of comparable age one might have a measure of 17-ketosteroid derived from testis precursors in men. This should be particularly true of the sex difference in Pincus reaction values since this reaction excludes certain (but not all) adrenal derivatives that might complicate the calculation. Unfortunately such calculation cannot correct for possible sex differences in the *quantity* of adrenal derivatives. Nonetheless, we have made the calculations using the mean values of table 1 and 2 and averaged the data into 3 age groups in table 12.

These data contrast markedly with those of the preceding table (11). There is a consistent decline with age for each collection period, and this would point to a decline in testis precursors with age. There is, however, no reason *a priori* to suspect a testis response to the stress of waking, so the higher values for the waking specimens (over the sleep specimen values) suggest the inclusion, at least for these waking values, of an adrenally-contributed component. This component may be approximated by subtracting the Pincus reaction derived values

TABLE 12. THE MEAN DIFFERENCE BETWEEN MALE SUBJECTS' VALUES AND FEMALE SUBJECTS' VALUES IN THE MEAN ZIMMERMANN AND MEAN PINCUS REACTION VALUES FOR URINARY KETOSTEROIDS IN 3 AGE GROUPS.

	Men — Women. Mg. per Hr.								
Age Range	Zimmermann (I)			Pincus (II)			I — II		
(Years)	Sleep	Waking	Day	Sleep	Waking	Day	Sleep	Waking	Day
20-49	0.142	0.234	0.141	0.146	0.206	0.118	—0.004	0.028	0.023
50-69	0.113	0.167	0.112	0.118	0.145	0.094	—0.005	0.022	0.018
70-99	0.066	0.066	0.052	0.041	0.066	0.044	0.025	0.000	0.008

from the Zimmermann reaction derived values; this has been done in table 12, and it may be seen that it is in practically all cases of a low order of magnitude (ranging from 0 per cent to, in one instance, 38 per cent of the Zimmermann value) and that there is no suggestion of a decline with age in the sleep values and some indication of age decline in the waking and day values. In brief, the derived "testis-contribution" is consistently age-conditioned whereas the derived "non-testis contribution" is small and less consistently age-conditioned.

The foregoing analysis of the 17-ketosteroid excretion values suggests these conclusions: (a) the presence of adrenally contributed components which vary in amount with age much like the neutral reducing lipids and are notably sustained in the most basal state, sleep, (b) the presence of testis contributed components in the men which decline in amount regularly with advancing age, and (c) the presence of certain 17-ketosteroids derived from adrenal precursors which decline regularly with age. These last are best illustrated by the 17-ketosteroid outputs of the women, but are undoubtedly present in the men's 17-ketosteroid array. It is suggested that the precursors of these are chiefly 11-desoxy steroids from the adrenals, perhaps an adrenal androgen such as Δ^4-androstene-3,17-dione (and/or dehydroepiandrosterone).

Estrogens.—A marked sex difference is observed in the data for estrogen excretion. Presumably the estrogens of men may originate from the adrenal cortex and the testis, those of women principally from the ovaries in the early decades and thereafter from the adrenals and the ovaries. The rather constant output at all ages in the data for the men suggests a minor testis contribution, or a taking over of the testis contribution by increasing adrenal contribution in the latter decades, or an unimpaired estrogen-producing capacity of the testis despite clearly impaired androgen-producing ability. Our data do not permit any selection among these possibilities. The adrenal estrogen seems to be estrone since it has been definitely isolated from adrenal tissue (1). Estrone, however, is readily metabolized to the other two estrogens found in urine so that its decline in the urine in older men (fig. 7) does not necessarily indicate its secretory decline in the adrenal. Since estriol is a metabolic product of estrone and estradiol its rising output with age suggests merely a somewhat increased metabolism of its precursors or its lowered utilization.

The changes with age in estrogen output in women are reflective initially of ovarian secretory capacity which, as one would expect, declines with increasing age. The rather constant output in the later decades may be reflective of sustained adrenal secretion or even the ingestion of a constant small amount of estrogen in food which is in turn in part excreted. This is not too likely since measurements of estrogen in food (7) have disclosed too low a content to account for all of the excretion here observed.

Androgens.—It is interesting that the obvious sex difference in estrogen excretion is not so marked when one examines the data for androgen output. The androgenic activity in the neutral ketonic extract is due principally to androsterone, and we have previously noted that androsterone is a metabolite of adrenal as well as testis origin. In the case of the men's data it may be deduced that the steep decline (fig. 6) to the fifth decade is largely reflective of declining testis production of urinary androgen precursor and that the slower decline thereafter is reflective of a checking of testis secretory diminishment or a considerable adrenal contribution. The women's data are somewhat more puzzling, but the simplest explanation of their parallel androgen output decline to the fifth decade is the suggestion of an ovarian product which is an androgen or is metabolized to androgen. The very nearly constant androgen output by women in the sixth to the ninth decade may be attributed to an adrenal precursor diminishing only slowly with increasing age. It is unfortunate that although the major ketonic androgen of younger persons is well established as androsterone, no positive assertion about elderly persons' urinary androgen

may be made. The few cases of elderly persons examined by Dobriner (3, 4) suggest a marked reduction in androsterone output with little or no reduction in urinary androgens originating from adrenal precursors alone.

General.—That a number of steroids are low in concentration in the urine of aged persons has long been recognized. Quantitative studies of the rate of decline with age have, however, been limited to androgen (reviewed by Dorfman, 5) and 17-ketosteroid (reviewed by Mason and Engstrom, 14, and Dorfman, 5) output changes. It is clear from our data that there are very wide differences in the rate of decline with age in the different classes of steroids, but the explanation for these differences is not readily found.

We have indicated in our analysis that urinary steroids derived from certain adrenocortical precursors (e.g., the neutral reducing lipids) seem to be those which change least with age. Nonetheless, other metabolites from adrenocortical precursors do decline very markedly with age (e.g., 11-desoxy 17-ketosteroids). Much more specific information might be obtained about the secretory precursors of these substances if the components of the steroid mixture denominated as neutral 17-ketosteroids, non-ketonic neutral steroids, and neutral reducing lipids could be resolved and measured separately.

Thus Dorfman (6) has indicated how one may, from the measurement of the various urinary 17-ketosteroid components, derive an estimate of the quantity of precursors secreted. Fortunately also, methods for the resolution and measurement of the urinary corticosteroids are now available, e.g., quantitative extraction, separation by column partition and paper chromatography, and methods for steroid analysis in blood are also being rapidly developed[1]. The obvious next step is the application of these methods to the determination of specific substances. It is our expectation that this will be accomplished in the near future and that the number of interesting questions raised by the data of this paper may have some more definitive answer.

We believe that our data have implications for geriatric practice and that the general implication is caution. If it be considered that aging involves a deficit of certain steroids any rational attempt at replacement therapy must consider carefully which steroids are to be used. If one wishes to replace the secretory precursors of the urinary 17-ketosteroids our data suggest, but do not prove conclusively, that 11-desoxy precursors are involved. Until we can be certain of the exact chemical nature of these precursors attempts at replacement must be very chancy indeed. Thus testosterone is an excellent precursor of 11-desoxy urinary 17-ketosteroid, but so are Δ^4-androstenedione, 11-desoxycortisone, and 17-hydroxyprogesterone (cf. 6). How much of each in fact contribute to the 17-ketosteroid array? The apparent minor deficit of corticosteroid suggested by our data is complicated further by the lack of knowledge of specific precursors of the urinary corticosteroids. It is conceivable, for example, that in aged persons the secretion of biologically active corticosteroid is diminished and replaced by a relatively inactive secretory product. Until we can specifically characterize the secretory products in aged persons rational replacement therapy will elude us.

In one instance certain specific substances have been determined with some accuracy in our study—the estrogens. The general suggestion is that replacement therapy is not needed in the male, but when the separate estrogens are considered small deficits in estradiol and estrone are suggested in the face of an increase of estriol (fig. 7). Here the deduction for replacement therapy (if justified) is not easy to make since the possibility for differential estrogen metabolism inheres in this type of data. What is indicated is the need for determining by appropriate estrogen administration studies whether older men do in fact metabolize estrogen differently from younger men. In fact all of these urinary steroid excretion data are open to examination from the point of view of differential metabolism of precursor sub-

[1] Steroid analytic methods are presented in detail in Recent Progress in Hormone Research *9:* (in press, 1954).

stances, and we are in the process of conducting such studies.

Summary

Quantitative measurement has been made of urinary neutral ketonic steroid (I), by two color reactions, of neutral non-ketonic steroid (II), of neutral reducing lipid (III), of estrogen (IV) as estradiol, estrone, and estriol by bioassay, and of total ketonic androgen (V) in appropriate extracts prepared from the urines of adult men and women of various ages. The diurnal variations of output of I, II, and III have been determined in the various age groups.

A fairly regular and marked decline of output of I with age has been observed in both men and women. No significant decline with age in the basal output of III is observed in either sex, and the data for II exhibit a moderate rather regular decline with age. It is pointed out that these differences in age output data exhibited by these 3 classes of steroids probably inheres in the rate of production of their secretory precursors; the production of certain 11-desoxy adrenal precursors would seem to be most subject to decrement with age whereas the production of certain characteristic corticoids may be least age-labile.

The diurnal rhythm of excretion of I, II, and III tends to be abolished in aged subjects, but the persistence of significant diurnal rhythms is different for the 3 different classes of compounds. A marked decline in total estrogen excreted by women occurs during the third to sixth decades with a constant low level of output thereafter. No significant change of total output with age is seen in the men's data.

When the separated urinary estrogens are considered they roughly parallel the total estrogen decline in the women's data, but estriol declines most steeply and estrone least steeply in the third to sixth decades. In the men's data a small increase of estriol output with age is indicated, accompanied by small, but apparently regular declines in estrone and estradiol excretion. A sharp decline (sharpest in the men's data) of androgen output is seen in the third to fifth decades in both sexes with a lesser decline thereafter. Characteristic changes in the variability of the mean data in relation to age are presented.

The implications of these data for the probable secretory precursors of the classes of urinary steroids measured are discussed as well as certain implications for geriatric practice.

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222 Maple Avenue, Shrewsbury, Massachusetts.

CHOLESTEROL AND ANTILIPFANOGEN IN ARTERIOSCLEROSIS

HENRY S. SIMMS, PH.D., CHARLES R. HARMISON, PH.D., AND REGINA B. BEST

(From the Department of Pathology, College of Physicians and Surgeons, New York)

We have previously published evidence (14, 15, 16, 17, 18, 19) that the "lipfanogens" in blood plasma are involved in the fat deposition of atherosclerosis. These substances are found in all sera, partly in a free state and partly combined with "antilipfanogen" to form a complex. They are observed by placing them in tissue culture media where they are taken up by the living cells and are converted into visible fat granules. They may be defined as follows:

Lĭp - făn' - ō - gĕn(s) (from the Greek λιπος fat + φανερος make visible + γενειν to produce) — Substances that produce visible fat. A special group of lipoid[1] substances found in blood serum which, when in a free state, are taken up by living cells and converted into visible fat.

We have also published evidence (16, 17, 18, 19) that the "antilipfanogen" in blood serum serves as a regulating agent that reduces or prevents the fat deposition of atherosclerosis. It may be defined as follows:

Anti" - lip - fan' - o - gen A substance found in blood serum that reduces or prevents the fat depositing action of the lipfanogens that are present.

Antilipfanogen has been shown to combine in part with the lipfanogens, forming a complex that is not converted into visible fat.

The evidence may be briefly summarized as follows:

1. In a species, such as the chicken, having a greater incidence of atherosclerosis than humans, the free lipfanogens in the serum are higher and the free antilipfanogen is lower than in humans.

2. Conversely, in species (dogs, horses, cattle) having a lower incidence of atherosclerosis than humans, the free lipfanogens are definitely lower and the free antilipfanogen higher than in human serum.

3. Human males seem to have slightly more free lipfanogens and less free antilipfanogen than the human female.

4. In diseases typified by hypercholesterolemia and associated with high incidence of atherosclerosis (coronary disease, diabetes, and nephrotic syndrome) the free lipfanogens were found to be higher than normal and the free antilipfanogen lower than normal.

5. Segments of chicken and of human arteries incubated in vitro in a suitable medium containing lipfanogens developed deposits of sudanophilic fat, while control segments remained free from stainable fat. These experimental deposits in chicken arteries closely resembled the spontaneous atherosclerosis in that species (16).

6. Any desired degree of fat deposition can be obtained in vitro merely by varying the relative concentrations of antilipfanogen and of lipfanogens in the media.

In other words, wherever atherosclerosis is prevalent free antilipfanogen is low and free lipfanogens are high—and vice versa. Furthermore, since these fat depositing lipfanogens are in continuous contact with the intimal surface of the blood vessels, it is logical to assume that they would be involved in any fat deposition that takes place.

On the other hand, it has been the belief of some workers (1, 5, 8) that cholesterol constitutes the fatty material primarily deposited in

[1] The word "lipoid" is used in this paper in preference to the more commonly used "lipid." Lipoid has a legitimate and acceptable derivation (from the Greek λιπος fat, and ειδος form). It was used by Kletzinski in the last century and was reintroduced in 1901 by Overton. In 1910 Leathes used the term "lipin." Later the word lipid came into use, but it has a Greek root with Latin suffix, and lacks appropriate connotation.

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atherosclerosis. This does not agree with our conception of the mechanism.

This paper has two purposes, first to point out that the primary deposit of fatty material in atherosclerosis is predominantly sudanophilic fat, and second to present experimental evidence that the high fat deposition in hypercholesterolemia may be due to the liberation of free lipfanogens because of the formation of a complex between cholesterol and antilipfanogen.

Primary Fat Deposition.—The following observations indicate that the fat primarily deposited is predominantly sudanophilic:

1. Previously unpublished studies in this laboratory on frozen sections of very small sclerotic plaques from the human aorta showed that in these (presumably early) plaques there were diffuse fat droplets that stained with Sudan IV, but no histologic indications of cholesterol. (Note: This diffuse fat was so easily soluble that care was required not to dissolve it while staining. Prolonged exposure of the sections to 65 per cent alcohol saturated with Sudan IV avoided this difficulty, although the staining was faint.)

As progressively larger plaques were observed, cholesterol accumulations were seen, becoming increasingly conspicuous. Similar results were obtained by Duff and McMillan (6). Furthermore, Meeker and Jobling (11) found, by chemical analysis, that neutral fat predominated in the smaller plaques and cholesterol in the larger ones. These observations have been verified by Buck and Rossiter (3) and by Fangman and Helling (7).

2. Experimental feeding or injection of *cholesterol* gives an initial deposition of *stainable fat* (2, 12).

3. Although hypercholesterolemia is widely accepted as being accompanied by high incidence of atherosclerosis, there is no evidence that cholesterol itself is the primary depositing material.

If we accept the premise that the primary fatty deposits are predominantly stainable fat, the question arises as to the source of this material. Our evidence indicates, as explained above, that the lipfanogens constitute the source of part or all of this material.

Cholesterol and Antilipfanogen.—If that is true, then an explanation is needed of the fact that high serum cholesterol results in the deposition of the lipfanogens in the form of visible fat. There seems to be only one explanation that fits the known facts, namely, that cholesterol also forms a complex with antilipfanogen and that there is competition between the cholesterol and the lipfanogens in their combination with antilipfanogen.

However, up to the present we have had no experimental proof that this was true. Therefore, after overcoming various technical difficulties, we performed a series of experiments in which colloidal cholesterol was added to tissue culture media containing fixed amounts of lipfanogens and of antilipfanogen (together with inactive controls). The resulting increase in free lipfanogens and decrease in free antilipfanogen were observed by determining the degree of formation of visible fat in the various cultures.

Experimental

We have conducted 10 similar experiments. A typical one is reported in detail herewith. The solutions that were used are described below.

Preliminary Solutions

1. *Solution of Ether-Soluble Lipfanogens Plus Heated Albumin.*—A 9 ml. sample of chicken serum was diluted with 27 ml. of water and heated at 89 C. for 30 minutes (thus killing the antilipfanogen). The cooled dilute serum was extracted 3 times with an equal volume of ether. The pooled extracts were evaporated nearly to dryness on a steam-heated waterbath, then moistened with 2 ml. of ethyl alcohol and again evaporated. The last step was repeated to drive off the last of the ether, taking care not to reach complete dryness. To remove the alcohol, 3 ml. of water was added and carefully evaporated. This was repeated, giving a milky lipoid suspension containing

active lipfanogens. Water was added to give 9 ml. and to the suspension was added 4.5 ml. of a solution containing 5 per cent of Cohn's serum Fraction V. Water was added up to 18 ml., giving a solution containing the ether-soluble lipfanogens from 9 ml. of chicken serum, plus 1.25 per cent of serum albumin. The solution was autoclaved in order to sterilize it and to destroy the antilipfanogen in the albumin.

2. *Colloidal Cholesterol Solution in Water.*—The procedure was adapted from that of Dewey (4). A sample of cholesterol weighing 600 mg. was dissolved in 50 ml. of warm acetone. Warm water was then added dropwise with vigorous stirring to the point of cholesterol precipitation. A few milliliters of warm acetone was added slowly until the precipitate just redissolved. This solution was then added dropwise, with vigorous stirring, to 100 ml. of water. An opalescent and milky solution was obtained, free from cholesterol "curds." The acetone was removed by warming gently under partial vacuum. The few curds that separated were removed by filtration through a glass wool plug, giving 85 ml. of a milky white solution with a slight opalescence but with no crystals visible under the microscope. Analysis of this solution for cholesterol by a modification of the Sperry and Schonheimer method (13) gave a cholesterol content of 277 mg. per 100 ml. The solution was sterilized by autoclaving. Stabilizing agents, such as serum proteins, could not be added to this solution because their lipfanogenic activity could not be properly controlled. However, heated albumin served as a stabilizer by being incorporated in the lipfanogen solution.

3. *The so-called XMI and XMII concentrated mother solutions required to constitute our "X6" physiologic solution (16)—sterile.*

Final Solutions Used on the Tissue Cultures

1. *Lipfanogen Plus Heated Albumin Control Solution* (abbreviated to "L + Ha solution"). This was made up from sterile solutions as follows:

3.0 ml. of the solution of ether-soluble lipfanogens plus heated albumin
+ 6.0 ml. of sterile distilled water
+ 0.5 ml. of XMI solution
+ 0.5 ml. of XMII solution
= 10.0 ml. total L + Ha solution—sterile.

2. *Lipfanogen Plus Heated Albumin Plus Cholesterol Solution* (L + Ha + C solution)

3.0 ml. of the solution of ether-soluble lipfanogens plus heated albumin
+ 6.0 ml. of the colloidal cholesterol solution in water
+ 0.5 ml. of XMI solution
+ 0.5 ml. of XMII solution
= 10.0 ml. total L + Ha + C solution—sterile.

3. *Unheated Antilipfanogen Solution* (active)—"UA solution"

0.625 gm. serum fraction V (Armour batch K11203)[1]
+ 12.0 ml. distilled water
+ 1.0 ml. XMI solution
+ 1.0 ml. XMII solution
+ 0.9 ml. 0.1M NaOH to bring to pH 7.3

plus distilled water to a volume of 20.0 ml. This solution was sterilized by filtration through a glass pressure filter[1] (fig. 1). To 7.5 ml. of the above solution, 1.7 ml. of ox serum ultrafiltrate[1] was added, giving 9.2 ml. of UA solution.

4. *Heated Antilipfanogen Solution* (inactivated control)—"HA solution." Another 7.5 ml. portion of the above solution was heated at 89 C. for 30 minutes to inactivate the antilipfanogen. Then 1.7 ml. of ox serum ultrafiltrate was added, giving 9.2 ml. of HA solution.

5. *Dilute Serum Ultrafiltrate.* "UF/5." Sterile ox serum ultrafiltrate was diluted with 4 parts of X6 solution and was kept stoppered

[1] The source of the antilipfanogen used in this work was Fraction V of ox serum proteins prepared by Armour and Company, Batch No. K11203.
The ox serum ultrafiltrate was prepared by Microbiological Laboratories, Bethesda, Maryland.
The pressure sterilizing filter shown in figure 1 was made by E. Machlett and Son, 220 East 23 Street, New York, New York.

under an atmosphere containing 5 per cent CO_2 in air.

Tissue Culture Tests

Cultures of adult chicken aorta fibroblasts were prepared free from fat granules, using our routine technique, as previously described (14, 16). Forty of the best cultures were selected for this experiment. Using sterile technique, they were treated with the above 5 solutions in the amounts indicated in table 1, columns 3 to 7. The number of multiplicate cultures treated with each medium is indicated in the second column. For example, 5 sister cultures were treated identically with medium No. 4, consisting of 0.7 ml. of L + Ha solution, plus 0.3 ml. of UA solution, giving a total of 1.0 ml. of fluid medium placed on top of the thin plasma clot of the cultures. The pH of all the cultures was adjusted to 7.3, using sterile CO_2—air mixtures (about 4 per cent), and the cultures were kept at 37 C. for 48 hours (with any necessary pH adjustments in the meantime).

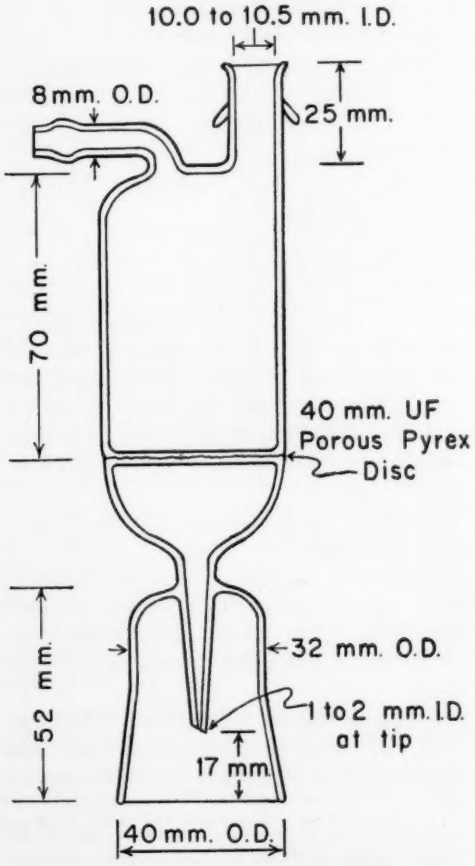

FIG. 1. Glass pressure filter—50 ml. size—for sterilizing solutions.

At the end of 48 hours the cultures were removed from the incubator and divided into 2 groups—those with active antilipfanogen and those with inactivated antilipfanogen (or none). The culture flasks in both groups (each having been marked with a code number) were rearranged in random sequence so that the observers would not be aware of the identity of the cultures without consulting the records.

The cultures were then examined under the microscope by 4 observers, working independently, and were rated for the degree of fat deposition on a scale from 1 to 9 (with intermediate half values, such as 4½) as previously described (17). The 4 values obtained by the 4 observers on each flask were averaged. These averages were, in turn, averaged with those of the other identical cultures having the same medium. The mean fat ratings thus obtained on cultures containing unheated (active) antilipfanogen are designated by the symbol R_U (column 8), whereas the ratings on control cultures containing heated (inactive) antilipfanogen are designated R_H (column 9).

This method of using multiplicate cultures for each medium and averaging the ratings of several experienced observers gave us much more accuracy than would have been possible otherwise.

From the mean culture ratings R_U in column 8 we obtained the corresponding lipfanogen values (L_F in column 10) for the free lipfanogens[1]. These are read from a table based on

[1] One lipfanogen unit is the fat depositing activity of a concentration of lipfanogens which, in standard media under standard conditions, will in 48 hours produce a few fat granules barely detectable in a single high dry field (with an average fat granule volume of 1.6 cu. μ per cell).
The lipfanogens vary in their activity. Thus 0.05 mM. sodium stearate has a lipfanogen activity of one unit, whereas only 0.0005 mM. of sodium oleate has the same activity.

TABLE 1. EXPERIMENTAL DATA

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Medium No.	Number of Identical Cultures	Volume of Each Solution Added to Culture Flasks Total = 1 ml.					Mean Fat Ratings[1]		Corresponding Lipfanogen Values		Computed Values[2]		
		Lipfanogens Plus Heated Albumin		Antilipfanogen		UF/5							
		Control L+Ha	+Colloidal Cholesterol L+Ha+C	Unheated UA	Heated HA		Unheated R_U	Heated R_H	Free L_F	Total L_T	Complex $= \Delta L = L_T - L_F$	Free Antilipfanogen A_F	Apparent Total Antilipfanogen A_T
1	2			0.3 ml.		0.7 ml.	0.67		0.8				
2	2				0.3 ml.	0.7 ml.		5.25		19.3	18.5	72	90
3	2	0.7 ml.				0.3 ml.		6.71		51.5			
4	5	0.7 ml.		0.3 ml.			3.78		7.0[4]				
5	4	0.7 ml.			0.3 ml.			6.91		58.0	**51.0**	**23**	74
8	4	0.5 ml.	0.2 ml.	0.3 ml.			4.31		9.8				
9	3	0.5 ml.	0.2 ml.		0.3 ml.			6.64		49.5	**39.7**	**12**	52
14	4	0.2 ml.	0.5 ml.	0.3 ml.			4.67		12.8				
15	3	0.2 ml.	0.5 ml.		0.3 ml.			6.55		46.5	**33.7**	**8**	42
18	5		0.7 ml.	0.3 ml.			4.92		15.0				
19	4		0.7 ml.		0.3 ml.			6.71		51.5	**36.7**	**7**	44
20	2		0.7 ml.			0.3 ml.		(Degen.)[3]		....			

[1] Each "Mean Fat Rating" is the average of the ratings of a number of identical cultures (second column). Each culture was rated independently by four observers, and their values averaged, as described in the text.

[2] The values in the last three columns were computed by equations (2), (3) and (4).

[3] "Degen." means that the cultures were degenerate.

[4] The bold face numerals represent values discussed in the text or plotted in fig. 2.

the previously computed relationship (17) which may be expressed by the equation:

$$L = 0.5 \cdot 10^{0.3R} \qquad (1)$$

Similarly, the total lipfanogens L_T in column 11 were obtained from the R_H values in column 9.

For each pair of media identical with each other except that one contains unheated antilipfanogen while the other heated antilipfanogen, there is one L_F value and one L_T value. From these 2 values it was possible to compute the values in the last 3 columns of the table.

The concentration of the complex between lipfanogens and antilipfanogen (column 12) is equal to the difference between the total and free lipfanogens:

$$\Delta L = L_T - L_F \qquad (2)$$

The apparent total antilipfanogen[1] is given by the formula:

$$A_T = \Delta L(1 + \frac{k}{L_F}) \qquad (3)$$

where the value of k was taken as 3.1. (We know now that these A_T values do not include the antilipfanogen that is combined with the cholesterol.)

The free antilipfanogen is equal to:

$$A_F = A_T - \Delta L = \frac{\Delta L k}{L_F} \qquad (4)$$

These formulas follow from a previously demonstrated equilibrium equation (17) that can be put in the form:

$$k = \frac{L_F A_F}{\Delta L} \qquad (5)$$

Technical Difficulties

It was necessary to overcome a number of technical difficulties before we succeeded in obtaining results that satisfied us as to their significance. These included:

1. Obtaining a satisfactory colloidal solution of cholesterol, having high enough concentration, but free from stabilizing agents, especially from lipfanogenic materials (such as would be present in serum or its fractions).

2. Preventing precipitation of cholesterol during sterilization.

3. Preventing precipitation in culture media, with possible carrying down of lipfanogens or of antilipfanogen.

4. Planning our media so that we could have proper controls. The "L + Ha" solution was a control on the "L + Ha + C" solution. Also heated antilipfanogen was in a sense a control on unheated antilipfanogen. In both cases the pair of solutions differed by only 1 variable. It was necessary to make them up in such a way that all the other constituents were identical. To this end, the heated albumin used as a stabilizer was added to the lipfanogen solution rather than to the cholesterol solution.

5. Obtaining significant accuracy in observing small differences in lipfanogenic activity. This was done by means of multiplicate cultures and multiple observers, as described above.

Observations

The results are given in table 1. It will be seen in column 13 that, under the conditions of this experiment, a progressive increase in the concentration of cholesterol resulted in a progressive decrease in the free antilipfanogen. This is shown in figure 2. At the same time there was a decrease in the amount of antilipfanogen bound to lipfanogens (column 12 in table 1). Correspondingly, there was a progressive increase in the free lipfanogens (column 10, table 1) as is shown in figure 2. These are the same changes that we have found in hypercholesterolemia (18). The findings in this experiment agree with those of other similar experiments that have been performed in this laboratory.

Conclusions

It is concluded that these results demonstrate the existence of a cholesterol-antilipfanogen complex. With added cholesterol there was an increase in the amount of this complex, thereby depleting the amount of antilipfanogen available for forming a complex with the lip-

[1] One unit of antilipfanogen activity is that produced by a concentration of this agent such that, under standard testing conditions with lipfanogens present, a value of $A_T = 1$ (or $A_F = 1$) will be obtained when the L_T and L_F values are substituted in equation *(3)* or *(4)*.

fanogens. There was a consequent liberation of free lipfanogens, and these caused greater fat deposition.

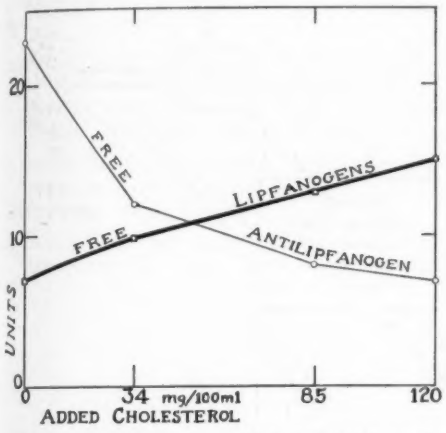

FIG. 2. The effect of colloidal cholesterol on the free antilipfanogen and on the free lipfanogens, as observed in tissue culture. The fat depositing activity is represented by the free lipfanogens.

A Concept of the Mechanism of Fat Deposition

The above findings, together with the evidence outlined at the beginning of this paper, indicate that the formation of a complex between cholesterol and antilipfanogen, such as we have demonstrated in vitro, can and does occur in vivo, and that it plays an important role in the etiology of atherosclerosis. We, therefore, propose the following concept of the mechanism of fat deposition in atherosclerosis:

1. That the primary fat deposition is sudanophilic fat.
2. That the accumulation of cholesterol is secondary.
3. That the free lipfanogens in blood serum constitute (in whole or in part) the material which is converted into, and deposited as, sudanophilic fat.
4. That these free lipfanogens increase as a result of a decrease in the free antilipfanogen.
5. That the free antilipfanogen decreases when there is a rise in serum cholesterol, since
6. Cholesterol forms a complex with antilipfanogen, the amount of the complex depending on the concentration of cholesterol.

In other words, hypercholesterolemia causes a binding of additional antilipfanogen, so that less of it is available for curtailing the fat depositing action of the lipfanogens.

The above concept applies to atherosclerosis resulting from hypercholesterolemia. However, it is believed that not all atherosclerosis is caused by high cholesterol (6, 9). It is to be expected that the lipfanogen-antilipfanogen balance might be upset by other means not involving cholesterol.

The relationship between these various agents is represented in figure 3, which is self-explanatory.

It should be pointed out that the fat deposition caused by the lipfanogens is a phanerosis and *not* a phagocytosis. Our concept does not agree with the theory of Leary (10) that phagocytes in the intima seize fat particles from the blood stream.

SUMMARY

The addition of colloidal cholesterol to tissue culture media containing known levels of antilipfanogen and of lipfanogens resulted in a lowering of the free antilipfanogen and *a liberation of free lipfanogens,* with consequent deposition of sudanophilic fat. The results indicate that a complex is formed between cholesterol and antilipfanogen.

The formation of such a complex seems to play an important role in the etiology of the atherosclerosis in so far as it is associated with hypercholesterolemia.

It is suggested that the primary fat deposition in atherosclerosis is sudanophilic fat resulting (in whole or in part) from the increase in free lipfanogens and that the accumulation of cholesterol in the plaques is secondary.

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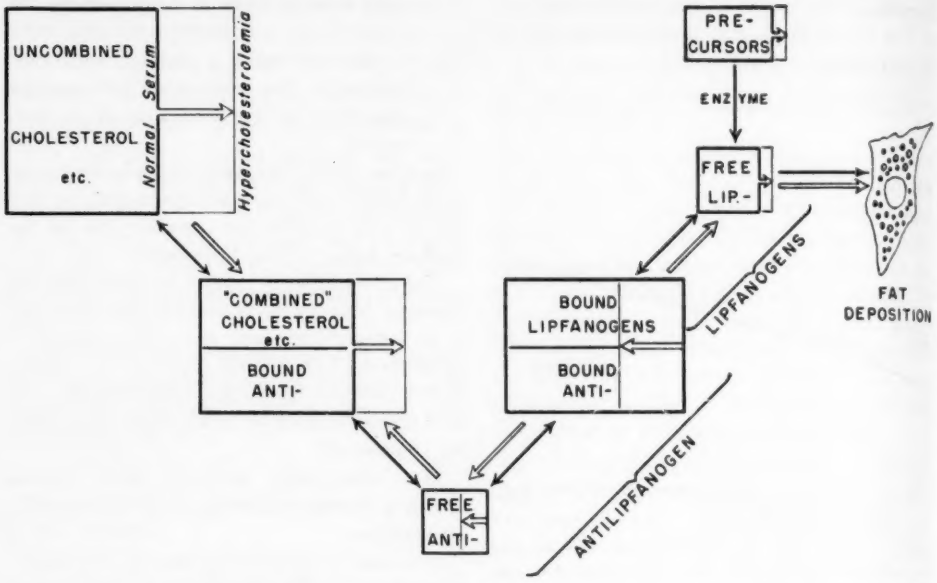

FIG. 3. The relationship between agents involved in fat deposition, as observed in tissue culture. The areas on the right are roughly proportional to the concentrations of these agents in normal human serum. The black arrows indicate the equilibrium in normal serum.

The 2 areas on the left (not proportional to those on the right) indicate the complex that is formed between cholesterol and antilipfanogen.

In hypercholesterolemia, changes are observed that are represented by the open arrows and the boundaries to which they point. The same changes are observed in vitro in the experiments described in this paper. They are, from left to right:

1. an increase in cholesterol
2. an increase in the complex between cholesterol and antilipfanogen
3. a decrease in free antilipfanogen
4. a decrease in the complex with lipfanogens
5. an increase in free lipfanogens and consequently
6. an increase in fat deposition.

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630 West 168 Street, New York 32, New York (Dr. Simms.)

HOMOTRANSPLANTATION AS A METHOD OF GERONTOLOGIC RESEARCH

E. GEIRINGER, M. D.

(From the Department of Pathology, Royal Hospital for Sick Children, Yorkhill, Glasgow, Scotland)

THE assessment in the intact animal of functional age changes of any tissue meets insuperable analytic difficulties because of the presence and interaction of other organs of the same age. It would, therefore, be of obvious advantage if we could transplant (without loss of function and without exciting adverse reactions) aged organs into youthful bodies and youthful organs into aged bodies. Ideally, this would enable us clearly to distinguish intrinsic age changes from those induced by aging or disease of the environing organism.

The execution of such a plan fails in most instances because of technical or biologic obstacles. Nervous tissue is biologically intransplantable. Its function depends on connections which once severed in the process of transplantation will not regenerate or could not be relied upon to reestablish normal contacts. The same applies, although to a lesser degree, to skeletal muscle and to any tissue which functions mainly by virtue of its nerve supply.

Organs such as the heart, lung, liver, alimentary canal, and kidney depend for their continued function after transplantation upon immediate and accurate reestablishment of their correct anatomical connections (vascular and ductal). The technical difficulty of achieving this precludes an attempt at homotransplantation in small laboratory animals. In larger animals where such procedures might be undertaken with some hope of success, we are still hampered by lack of sufficiently inbred strains. Homotransplantation of potentially antigenic tissues can only be successfully achieved at present in biochemically homogeneous strains.

The only organs with which this type of experiment can be attempted at the present time on a sufficient scale to yield useful results are the endocrine glands, which are independent of ducts, relatively independent of nervous control, and capable of discharging their specific functions with the diffuse blood supply, secondarily acquired after implantation. This disposes of most of the technical difficulties and makes it possible to use the method on the small laboratory animals of which there are strains sufficiently pure to allow successful homotransplantation.

The success of endocrine transplants is favoured, at least in the case of the adrenal gland, the gonads, the thyroid, and probably also the islet tissue, by the action of trophic hormones which stimulate the growth of glandular implants in animals deprived of the glands in question. In the case of the adrenal cortex, transplant survival is further enhanced by the fact that cortical hormones have a local protective effect against the absorption of incompatible transplants (1, 3) so that adreno-cortical transplants may be able to protect themselves during the critical time beyond which a homotransplant may become safe from the danger of absorption (15).

The conditions for successful adreno-cortical homotransplantation in the albino rat have been well defined (6, 7, 16) and this paper is an account of the application of this technique to gerontologic problems. An illustration of an adrenal-cortical transplant is shown in fig. 1. The animals used in all experiments were Wistar albino rats of the Glaxo strain.

Age of Transplant and Growth Rate

Material and Methods.—Fifteen male and 13 female rats from 4 litters obtained by mating 1 male with 4 female siblings, all born within five days of one another, were divided into 4 groups at the age of 8 months and treated as follows: 4 animals of each sex served as normal controls; 3 animals of each

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sex were subjected to bilateral adrenalectomy; 4 males and 2 females were subjected to bilateral adrenalectomy, followed by the insertion of the adrenal capsule of a sibling of

FIG. 1. Adrenal-cortical homotransplant to female rat. Transplant had been functioning for eleven months at the time of the animal's death, which occurred at the age of 2 years 8 months.

the same sex under the capsule of one kidney; 4 animals of each sex were subjected to bilateral adrenalectomy, followed by the insertion of the adrenal capsule of a newborn rat of the same sex under the capsule of one kidney. The donors were related to the hosts in being the offspring of mating the grandmother with one brother.

For twenty days after the operation the animals were given 0.9 per cent saline to drink. The weight of the animals was determined at frequent intervals. Six and a half months after the operation the experiment was terminated by killing the survivors.

Results.—The adrenalectomised animals in which no transplantation had been carried out all died shortly afer the substitution of water for saline. There was a marked sex difference in the survival time, the males dying 3, 4, and 8 days, and the females, 7, 14, and 15 days after return to water. In both sexes the loss of weight preceding death was about 20 per cent of the normal body weight, but in the males, this decline started while they were still on saline.

The average weights throughout the experiments of the 3 other groups are given in fig. 2. There was no significant difference in either sex in the over-all growth rate between the animals living on transplants and the normal controls. The females bearing newborn transplants, however, showed an accelerated growth for the first ten weeks of the experiment, gaining during this period as much as the males. Thereafter their growth rate reverted to that of the other females.

Discussion.—The growth rate of the normal adult rat shows a marked sex difference. Up to the age of ten weeks the 2 sexes grow at approximately the same rate. Growth then slows down rather abruptly in both sexes but more so in the female. This sex difference is partly caused by gonadal activity since it can be diminished but not abolished by gonadectomy. The above experiment suggests that the depression of growth in the female may also be contributed to by the activity of the adult adrenal cortex. This adreno-cortical effect could be autonomous or, more likely, the result of adreno-ovarian interaction. In the latter case the ten weeks of increased growth represent a period during which the maturing adrenal gland is refractory to ovarian influence or during which it is incapable of supporting

normal ovarian function (4, 10). The sex difference in the behaviour of the 2 groups with newborn transplants is either a true primary one or depends on the different biochemical relations of testis and adrenal as compared with ovary and adrenal.

That the adrenal cortex plays a part in the regulation of growth and that the prepubertal adrenal gland functions differently from the adult organ is indicated by many observations. Our purpose, however, is merely to demonstrate how suitably arranged experiments involving adreno-cortical homotransplantation can help to elucidate the exact nature of age changes in adrenal function. A repetition of the above experiments, using gonadectomized animals, could decide whether or not the change of adrenal function at ten weeks is dependent upon gonadal activity.

Summary.—Adult male and female adrenalectomized albino rats with coaeval adreno-cortical transplants and adult male adrenalectomized albino rats with newborn adreno-cortical transplants grew at the same rate as normal controls. Adult female adrenalectomized albino rats with newborn adreno-cortical transplants grew for ten weeks at an accelerated rate.

Cortical Transplants and Life Span

Material and Methods.—Eleven female rats, first cousins born within eleven days of one another, were divided into 3 groups at the age of 19 months and treated as follows: 3 animals served as normal controls; 4 animals were adrenalectomised and the adrenal capsule of a sibling of the same sex inserted under the left renal capsule; the remaining 4 animals were adrenalectomised and the adrenal capsule of a four weeks old female from the same strain was inserted under the left renal capsule. All animals were put on saline for seven days. They were kept in the same cage and their weights were determined at frequent intervals.

Results.—Within seven months of the experiment all the normal controls were dead, having reached the age of 1 year 11 months, 2 years, and 2 years 2 months, respectively.

In the group with the sibling transplants no deaths occurred and the animals at the time of writing are 2 years 5 months old. They have on the average gained 6 Gm. per month

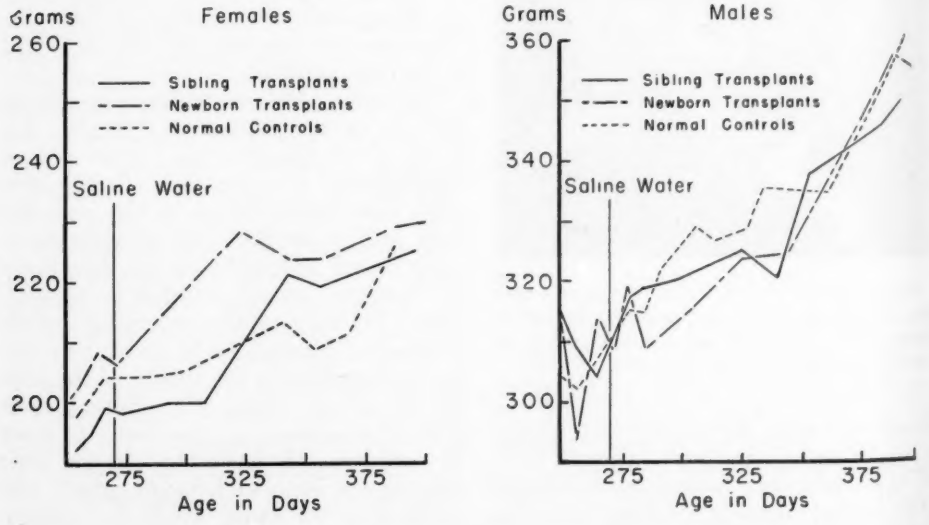

Fig. 2. Average weights of normal controls and adrenalectomized rats subjected to adreno-cortical transplantation at the age of 8 months.

since the operation, which is considerably in excess of the normal female growth rate at this age.

In the group with the young adrenal transplants 1 death occurred four months after the operation, that is, at the age of 1 year 11 months. At autopsy the transplant was found to be in process of absorption. The remaining 3 animals are still alive at the age of 2 years 5 months and have on an average gained 5 Gm. per month since the operation, which is considerably in excess of the normal female growth rate at this age.

Discussion.—The evaluation of this experiment turns to some extent on the question of the normal life span of the laboratory rat and on the actual causes of death. Under the conditions obtaining in this colony, the majority of rats die between the ages of 2 and 3 years from a chronic broncho-pneumonic process which usually starts at the age of about 1 year. The average life span of the Wistar albino rat under laboratory conditions is said to be about 2 years (11, 13), but until studies are published of a colony in which chronic lung infection has been prevented, the term life span must be understood in a restricted sense as meaning the age at which the laboratory rat usually dies of broncho-pneumonia. Any procedure which prolongs survival under these conditions must be interpreted as retarding the progress of the broncho-pneumonic changes rather than as having a fundamental influence upon natural life span.

So far, none of the animals in the above experiment have lived beyond the extreme ages reached in this colony. The survival of the transplant bearing animals as opposed to the death of the control group shows that adrenalectomy followed by homotransplantation need not shorten the life of the laboratory rat. A comparison of the 2 transplant groups has so far not revealed any difference in the behaviour of the animals with coaeval transplants and those with transplants one and a half years younger than themselves. The 1 death in the latter group was caused by late absorption of the transplant. It is to be understood that compatibility of transplants was more difficult to ensure in this group than in the controls with sibling transplants.

The striking increase in the growth rate in both transplant bearing groups is therefore not a function of the age of the transplant but must be because of a factor common to both groups. It has been shown that animals living on adreno-cortical homotransplants are in a state of mild chronic hypoadrenalism (8, 9, 17). It is also known that adreno-cortical secretions interfere with somatic growth (5, 14). These facts taken together might supply a sufficient explanation for the acceleration of growth and such an increase of growth potential might go hand in hand with an enhanced ability for repair and resistance, especially in view of what has become known about the interference with reactions to disease by adreno-cortical secretions.

It is therefore possible that normal adreno-cortical function may, under certain circumstances, be inimical to the survival of the senile rat; in other words, that part of the aging syndrome in the albino rat may be a relative hyperadrenalism. There are clinical and physiologic grounds for thinking that the picture of human senescence (especially in the female) may sometimes be partly conditioned by an absolute or relative hyperfunction of the adrenal cortex. Our intention here, however, is merely to show how the technique of homotransplantation can be used to acquire more precise notions on these fundamental points.

The advantage conferred upon the transplant bearing animals may consist partly in the denervation and demedullation of the adrenal gland which is a concomitant of homotransplantation. Suppression of the fright and flight reaction might be a disadvantage to a wild animal but may have an actual survival value to a laboratory animal, especially to one in a poor state of health. Whether this could account for the increase in growth rate observed in this experiment is doubtful, however. It is easy to devise experiments to answer these questions.

Summary.—In a group of senile rats the

normal controls died first. The experimental animals, which were adrenalectomised and had received adreno-cortical homotransplants, survived and have now reached the normal life span for the colony. They have also shown accelerated growth since the operation. No difference has so far been noticed between animals with coaeval and those with transplants one and a half years younger than themselves. It is concluded that adreno-cortical homo-transplantation need not shorten the life of an albino rat and that depression of adreno-cortical function in a senile animal may, under certain circumstances, prolong its survival.

This experiment takes us also one step further in the interpretation of the experiment on age of transplant and growth rate. In that experiment acceleration of growth occurred only in animals with immature adrenal transplants, while it took place in both animals with mature and with immature transplants in the second experiment. Moreover in the second experiment this acceleration was maintained indefinitely, while in the first it ceased after ten weeks.

The animals in the first experiment were mature females; in the second experiment they were post-climacteric senile females.

It seems, therefore, that an increase of adult female growth rate occurs under the following circumstances: 1) after cessation of ovarian activity with either mature or immature adreno-cortical transplants, but not with normal adrenals; 2) during sexual maturity, but only with immature adreno-cortical transplants. In addition, there is rapid female growth before puberty.

The most plausible hypothesis to cover these observations is that the depression of the adult female growth rate is a function largely of ovarian and partly of adrenal activity in the mature female and entirely of adrenal activity in the senile female. Gonadotrophic effects on the senile adrenal cortex provide the most likely mechanism for this functional transformation. If this is correct it would imply that an immature adreno-cortical transplant is not capable of maintaining normal ovarian function. This hypothesis can be tested in all its parts by experiment.

Cortical Transplants and Senile Alopecia

The concept of a relative hyper-function of the adrenal cortex in the senile rat gains a little support from the following experiment.

Material and Methods.—Fourteen female rats between 26 and 30 months of age were used in an attempt to study the feasibility of homotransplantation in animals of extreme old age. They were all weak and in various stages of senile decrepitude. Particular care was taken to record the skin changes at the start of the experiment. The skin of these animals was papyraceous, inelastic, and affected to a varying degree by a characteristic baldness seen in old rats chiefly in the nuchal region, over the back haunches, and on the lower (and later the upper) abdomen.

Operation was poorly tolerated and 8 animals died in the post-operative fortnight.

Two normal controls survived the stress of saline administration and continued their senile existence until they were killed two months after the start of the experiment. There was no noticeable change in their skin condition.

Two transplant bearing animals settled down to a normal senile existence and showed healthy big transplant nodules when killed two months after the start of the experiment. Both had sibling transplants. One showed no change in her skin while in the other the alopecia progressed slightly.

Two transplant-bearing animals, when killed two months after the operation, showed only small transplant nodules in process of absorption. One had a sibling, the other a newborn transplant. In both cases there was observed a remarkable regrowth of hair over the bald areas. At the same time the rest of the fur improved in quality. This improvement was maintained until the end.

Discussion.—Spontaneous cure of senile baldness has never been seen in this colony. Neither the controls nor the animals with

healthy transplants showed any regrowth of hair which was seen to a striking extent in the animals with poor transplant growth. It has been shown (2, 12) that adrenalectomy encourages hair growth, especially in the poorly nourished rat. It seems possible therefore that adrenal insufficiency was a factor in the regrowth of hair observed in this experiment. Since baldness of the type described is only, and very commonly, seen in the senile rat, this observation supports the idea that in respect to some features of senility the laboratory rat may be relatively hyperadrenal. That adrenal function may aggravate or bring out coexisting pathology (diabetes, hypertension, renal diseases) is beginning to be understood and it is in this sense that we shall probably have to interpret these findings in the rat.

Summary.—A form of senile alopecia seen in the Wistar Albino rat was unaffected in control animals and in adrenalectomised animals with healthy adreno-cortical homotransplants. Adrenalectomised animals with poor transplant growth showed a regrowth of hair over the denuded area.

The results of this experiment could have probably been obtained by any method producing adrenal insufficiency and homotransplantation was not essential. The next problem however cannot be tackled in any other way.

Lifespan of Adreno-Cortical Tissue

Material and Methods.—Two male control rats from the previous experiment were killed at the ages of 817 and 827 days. The capsules of their adrenal glands were inserted under the renal capsules of 4 adrenalectomised male rats aged 154, 154, 164, and 164 days, respectively. The animals were kept on saline for ten days and were then allowed to live the normal life of the colony. At the age of 1 year and 2 months 2 of the 4 animals were killed. Both animals were perfectly well and had reached the weights of 392 and 326 Gm., respectively. In each case a healthy transplant nodule was found growing on one kidney, adrenalectomy being complete. Fragments from both transplants were implanted under the renal capsules of 4 adrenalectomised male rats, 44 days old, weighing 85, 87, 95, and 115 Gm. They were kept on saline for ten days. These young animals have now remained well for one month after the operation, gaining weight at a normal rate. At the time of the second transplantation the adreno-cortical tissue was 3 years old.

Discussion.—In evaluating this experiment lack of knowledge of the natural life span of the rat should be borne in mind. The experiment is being extended to a great number of young recipients to insure against an accidental dying out of the strain of cortical tissue and it will be interesting to see how long the survival of this tissue can be prolonged. It is already clear that the actual limits set to the life span of the laboratory rat at present are not caused by an intrinsic functional deterioration of adrenal cortical tissue, since 3 year old adrenal tissue was capable of keeping adult male rats in a state of good health and is now supporting the normal life and growth of young animals. Apart from the maximum survival of adreno-cortical tissue which can be achieved by this method, a number of other interesting questions remain to be settled. Can such a transplant support the life of infant rats? Does the active regeneration following transplantation play a part in keeping this tissue youthful?

The experiment is reminiscent of the demonstration by Carrell of the indefinite survival of chicken fibroblast in tissue culture. The present instance is, however, of greater significance to students of mammalian gerontology since it can demonstrate the limits of survival in full functional activity, not of a primitive cell in an artificial medium, but of a highly specialised tissue within the animal organism. The possibility of thus segregating, by a series of investigations, "immortal" tissues of the body from those subject to intrinsic functional deterioration (aging) is very attractive.

Conclusions

These experiments are a small beginning and pose more questions than they answer but they

indicate at the same time the methods by which these questions may be solved. The simultaneous (albeit dyssynchronous) aging of the whole organism makes analysis of intrinsic aging mechanisms extremely difficult. Homotransplantation is the logical way out of this difficulty. By comparing function in animals of different ages bearing transplants of the same age with that in animals of the same age bearing transplants of different ages we shall at last begin to collect some facts concerning the origins and mechanisms of senescence. It must be borne in mind that the results of such investigations, furnishing information on the behaviour of transplanted tissues, are not necessarily and not always directly applicable to problems concerning normal organs. The use of normal controls can, however, largely overcome this drawback. It can easily be seen how an orderly extension of the experiments reported here would unravel the exact part played by the adrenal cortex in the aging process of the albino rat.

For reasons stated previously this technique must at present be largely confined to endocrine tissues. Even in this restricted field an enormous amount of work awaits the gerontologist. The procedure is applicable to the thyroid and gonads in the same way as it is to the adrenal cortex. For the anterior pituitary a slightly more complex approach will be necessary because of its partial dependence upon the integrity of its neuro-humoral connections with the hypothalamus. Islet tissue, because of its position within a vital exocrine gland, will also demand special treatment; its implantation will have to be preceded by selective destruction of the host's islet tissue, leaving his exocrine pancreas intact.

To extract all possible information from such experiments, patient and undisturbed team work over a number of years will be required at institutions where generations of animals can be followed under well standardised conditions throughout their life history. Such a development is not likely to occur in Britain at the present time.

The purpose of this paper is to stimulate by an illustrated description interest in what seems to be the only method at present at our command for the study of intrinsic age changes within the animal organisation. Technical details and discussion of results were restricted to a minimum because this is an article on the strategy of gerontologic research, not on its tactics, nor on its objectives.

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Department of Pathology, Royal Hospital for Sick Children, Yorkhill, Glasgow C 3, Scotland.

THE RELATION OF PROBLEM LENGTH IN SIMPLE ADDITION TO TIME REQUIRED, PROBABILITY OF SUCCESS, AND AGE

JAMES E. BIRREN, PH. D., WILLIAM R. ALLEN, B. S., AND H. G. LANDAU, PH. D.

(From the National Institutes of Health, the Institute for Air Weapons Research, University of Chicago, and the Committee on Mathematical Biology, University of Chicago)

SUBJECTIVELY a difficult task is one which requires a long time and one which has a low probability of a correct result. Little is known however about the nature of the relation between errors and the time required in perceiving or solving problems of varying difficulty, and there has been only a limited interest in the relation of speed of response and difficulty (5, 12).

Both time and errors are descriptive of the output of a human subject in response to some stimulus or input. Although we often use the subjects' errors as a measure of the input difficulty, we usually lack enough information about our stimuli to permit the desired analyses or inferences about the input-output relations.

The total time, T, to solve a problem is the sum of the times involved in the component events (or some portion of each component if they overlap), a point which will be developed in detail later in the present paper. Less obvious is the fact that the probability of a correct solution, P, is a function of the product of the probabilities of the component events. It seems plausible that the probability of getting a correct solution might be the product of a series of different functions of time, i. e., the probabilities associated with the times of the different events in deriving the answer. In the case where a longer total time results from a change in set or readiness to respond we may be observing an increase in time of a component event where the probability, P, is minimally dependent upon time, T, but still related.

The above relations assume importance because a progressive increase in reaction time has been reported in later life (6, 16). If P is an inverse function of T then one would also expect to see a drop in P in later life. The slow response of the elderly has been regarded by some as largely a non-psychologic change because mental measurements with time limits show greater decrement with advancing age than power tests or tests without time limits. One has to decide which of the age curves most properly represents aging of mental abilities, i. e., the curves with or without time as a component. Such issues require an understanding of the relations of P, T, difficulty, and age.

It should be mentioned that timing of mental tests is done in two general ways: 1) the time taken by an individual to solve a problem such that he is satisfied with his solution, and 2) the time required for his first answer. In the first case a subject in repeating the cycle of operations necessary to secure an answer raises the probability of a correct solution while simultaneously increasing the time. Thus after the first cycle of operations in solving a problem, P increases as well at T; whereas within the first cycle of operations P and T are likely to be inversely related. The present study implicitly uses the second case above in which a single cycle of operations is considered beginning with the presentation of a stimulus or problem to be operated upon and ending with a response.

A previous paper (1) suggested how age changes in T and P might be explored in a simple homogeneous task that could be experimentally varied in difficulty. The task consisted of adding single columns of digits of varying lengths. The independent measure of

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difficulty was the number of digits in the series or the number of addition operations. In that study, performance was expressed as the amount of work per unit time and no attempt was made to develop explicitly the relation of P to difficulty. Because only two narrow age groups were studied, no estimate was possible of how these relations might change with advancing age. The present study utilized the same task, simple addition, and attempted to determine in a larger series of subjects the relations of: time and difficulty; probability and difficulty; and the possible age changes in the parameters of these functions.

Methods

Materials.—Pages of single column addition problems of varying column length were prepared as previously described (1). Subjects were instructed to add the columns of digits as quickly as they could. For each length of problem the proportion correct, P, and time per column, T, were computed. In individually administered tests, two minutes per page or time to complete the page was used as the time limit. In group testing, a time limit of one minute each was used for the pages of 2, 3, and 4 digit problems, and a two-minute time limit per page was used for all longer problems (1).

Subjects.—A total of 413 subjects was tested in the age range 16 to 90 years inclusive (table 1). All subjects had English as their native language and had a minimum of four years of education. All subjects over the age of 60 were tested individually after screening for visual acuity in which the subjects were required to read orally pages of digits of the same type size as the test material. The subjects were students in a Baltimore high school, members of adult education classes of the Baltimore schools, convalescing patients in general hospitals, and selected residents of the Baltimore City Hospitals home for the aged. The high school and 60 year old subjects are the same groups as previously described (1).

Table 1. Distribution of Subjects' Ages and Type of Occupations

Age		16-20	20-29	30-39	40-49	50-59	60-69	70-79	80-89[1]
Subjects	n	193	34	35	33	28	46	29	15
Years of education	Median	11	12	14	11	9	8	7	8
	Range		8-16	8-20	8-17	4-17	4-17	4-12	6-12
Occupation									
Professional			1	2					
A. (Graduate training in specialty)			1	2					
B. (No graduate training, e. g., nurses teachers)			5	7	3	3		1	
Management									
A. Senior executive							1		
B. Junior executive				2	1	1	1		
Skilled (Machinist)					1	3	2	2	
Semi-Skilled (Machine operator)			2	3	12	10	23	11	
Sales representative							2	2	
Sales clerk			1	1	1	1	1	2	
Typist clerk			11	9	5	2	1		
Unskilled				2	1		7	6	
Housewife			5	9	8	4	2	4	
Students		193							
Miscellaneous			9		1	4	6	1	

[1] Information about previous occupations not available.

Results

The time required to add a series of digits increases as a function of the number of digits or addition operations. In the present data this relation was best described by the empirical equation

$$T(n) = Kn^m; \qquad (1)^1$$

where T(n) is the total time required for a problem of n addition operations in length, (n + 1 digits), and K and m are constant for an individual or for an age group. The observed mean points and lines of best fit are given for 3 age groups in figure 1. The forms of the fitted equations can be justified in part by the considerations outlined in the later sections of this paper. The least squares method of fitting was used because it minimizes the variance of the estimates of the parameters.

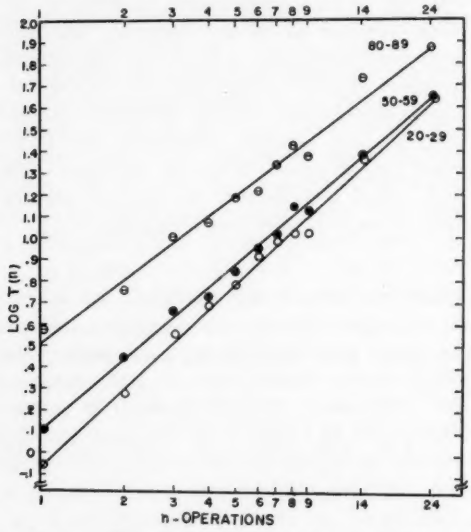

FIG. 1. Time per problem, T(n), as a function of problem length, n. Mean values and lines of best fit are given for 3 age groups. Data are plotted in the form, log T(n) = log K + m log n.

The values of K and m in expression (1), $T(n) = Kn^m$, change with age as shown by the results obtained from fitting of the data of successive age groups (table 2). The value of m seems to approach a limit of 1 in the oldest groups, whereas K seems to rise with positive acceleration in later life. This increase in K appears analogous to the increase in simple response time in later life (16). For the aged the time required to add a series of digits approximates a linear function of the number of addition operations required, i.e., the exponent m is about (approaches) 1 in equation (1).

The observed points to which the above expression was fitted were median values. This measure of central tendency was used because of the marked skewing in the distributions of time scores.

TABLE 2. PARAMETERS DERIVED FOR EACH AGE GROUP IN THE EXPRESSION $T=Kn^m$

Age	K	m
16 - 20	.89	1.26
20 - 29	.85	1.26
30 - 39	.88	1.18
40 - 49	.90	1.12
50 - 59	1.24	1.11
60 - 69	1.58	1.07
70 - 79	3.31	.97
80 - 89	3.23	.98

Because of the age changes in the constants in the above expression, the young and the aged are more nearly alike in the amount added per unit time (work) for long problems than for short problems. The variables, addition operations per unit time, problem length, and age, describe a surface illustrating this feature. The empirical surface for the present data, uncorrected for wrong answers, is shown in figure 2.

Not only the age change in time required per

[1] Equation (1) may be developed from the one previously reported (1) for the mean operations per second as a function of problem length, $Y = \frac{A}{X^n}$; Y was the mean operations per second, X the number of addition operations in the problem and A and n were constants. To solve for total time T(n) we use $Y = \frac{X}{T(X)} = \frac{A}{X^n}$, or $T(X) = \frac{1}{A} X^{(n+1)}$. The latter equation is equivalent to (1) above and in terms of the present notation $\frac{1}{A} = K$; $n + 1 = m$ and $X = n$.

problem but also the probability of a correct answer is of interest. Thus, as one systematically increases the length of a problem the

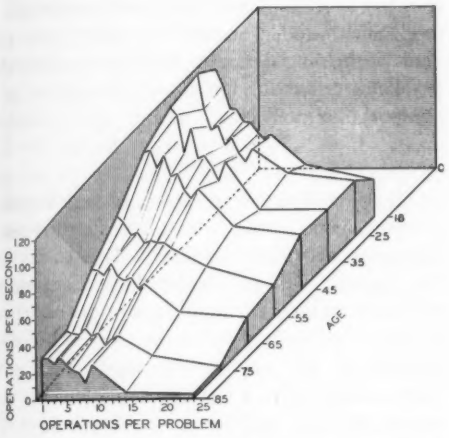

FIG. 2. The relations of addition rate, problem length, and age.

probability of a correct answer should be expected to decrease. In the present data this relation was best described by the empirical equation,

$$P(n) = P_o e^{-an}; \qquad (2)$$

where $P(n)$ is the probability of a correct answer to a problem of n operations in length, and P_o and a are constants. This equation describes the probability of a correct answer for short problems only, i. e., less than 10 digits. For longer problems there was an apparent increasing curvilinearity in the relation of log $P(n)$ to n which could not be evaluated in the present data because of the unreliability of the probabilities determined for the long series. It is suggested that the relation may be more closely approximated by

$$P(n) = P_o e^{-an - bn^2} \qquad (3)$$

in long series. The constant b is largely dependent upon the probabilities derived from the longer problems where in the present data the error of measurement was greatest, i. e., only a few problems could be completed in the time limits. It is apparent that the value of b is small in the present data (fig. 3). Thus for short problems the relation is approximately linear in the form

$$\log_e P(n) = \log_e P_o - an; \qquad (4)$$

the expression used in fitting the data.

The observed points and the lines of best fit are shown for 3 age groups in figure 3. In this figure the log probability is plotted against the number of operations per problem. The constants in the equation *(2)*, as derived from the least squares fits for successive age groups, are given in table 3. The observed points used in fitting the curves were obtained by dividing the sum of the number of problems correctly added by the number of problems added, i. e., $\frac{\Sigma N_c}{\Sigma N}$. As in the distributions of time scores, the distribution of probability scores for individuals on a particular length of problem is markedly skewed. For very

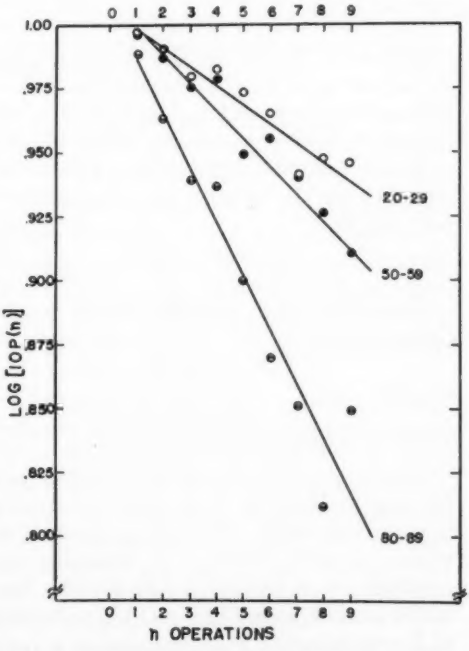

FIG. 3. The relation of the probability of a correct answer, $P(n)$, to the length of problem or number of addition operations, n. Lines of best fit and mean values are given for the 3 age groups. Data are plotted in the form, log $[10\ P(n)] = P'_o - bn$.

short problems, 2, 3, 4 digits, the median P as well as the mode are often 1.0.

The measure of central tendency used above, $\frac{\Sigma N_e}{\Sigma N}$, gives some weight to the probabilities less than 1.0 and thus fits the intuitive notion that there is always a slight probability of making an error regardless of the simplicity of the problem, i. e., even in 2 digit additions.

TABLE 3. PARAMETERS FOR EACH AGE GROUP IN THE EXPRESSION $P(N) = P_o e^{-an}$

Age	P_o	$-a$
16 - 20	1.01	.010
20 - 29	1.00	.007
30 - 39	1.01	.008
40 - 49	1.01	.007
50 - 59	1.01	.010
60 - 69	1.00	.012
70 - 79	1.02	.025
80 - 89	1.00	.021

Having the probability of a correct answer, P, and the total time, T, required to solve a problem both expressed as functions of n, the number of addition operations, implies that the probability could be expressed as a function of time. Solving the equation *(1)*, $T(n) = Kn^m$, for n we have,

$$n = \left[\frac{T(n)}{K}\right]^{1/m} \qquad (1.1)$$

Substituting this expression for n in the equation *(2)*,

$$P(n) = P_o e^{-an},$$

we get

$$P(n) = P_o \exp\left[-a\left\{\frac{T(n)}{K}\right\}^{1/m}\right]. \qquad (5)$$

Such an expression, or a more complete one for long problems as well, would presumably hold for individuals. Thus as a subject is required to solve problems of increasing unfamiliarity (i. e., increasing difficulty) his time would increase accordingly and his probability of a correct answer would decrease as a function of the time required. In the next sections a rational development is attempted by means of assumptions about the frequency of occurrence of the various partial sums in addition and the various constant and iterated processes. In view of the preceding results it seems quite possible that one could develop a model or simulated system which would describe in large part the process of addition in the human subject. Such a model would very likely prove of value in helping define or localize problems of psychologic measurement and the nature of aging of the intellect.

THE MODEL

The block diagram in figure 4 is a schematic picture of one system which describes the performance of simple addition. The blocks in the diagram will be identified as they might occur for an individual adding a printed column of digits and writing down the answers. Modification of the system for orally presented digits, different types of information, operations other than addition, or different types of information output will be obvious.

I_E is the external information source, which in our case is a printed column of digits. I_R is the information receptor, in our case the eye, and S_E the exterior signal, a pattern of light rays. $S_E^{(1)}$, the first digit is received by I_{R_1} and transformed to an internal signal, $S_1^{(1)}$, i. e., the nerve impulse. The internal signal, $S_1^{(1)}$, is recognized as a digit by I_{R_2}, an information recognition unit, and a refined signal $S_2^{(1)}$ is sent to the adder or operational unit I_O where it is stored in the short term memory unit STM. The second digit $S_E^{(2)}$ is transmitted and transformed in the same manner until it leaves I_{R_2} as $S_2^{(2)}$. The introduction of $S_2^{(2)}$ into I_O acts as a code signal to release $S_2^{(1)}$ from the STM cell and the two signals are operated upon and transformed into a signal S_3 representing the sum which is stored in STM. The unit I_O thus performs the operation of addition and holds the partial sum until the next digit comes in when it in turn is added to the partial sum.

The information that the problem is over is transmitted to I_O as a code, either by the printed bar denoting the end of the column, by the absence of any further exterior signals, or some other means. S_3 is then released from

STM to I_{R_2} where it is recognized as an integer and is transmitted to a transmitter activator, T, as S_4 which patterns a sequence of motor unit responses and thus in turn activates an information transmitter I_t by sending on the signal S_5. I_t in this case is the hand which records the external S_E* as a mark at I_E*.

The blocks I_{R_2}, I_O, T, and their associated memory cells should correspond to functions of the central nervous system, but it is unwarranted to assume that they are localized, distinct functions as might be inferred from the diagram.

In order that the system and the above operations might describe the phenomenon of addition we assume the following about the system:

1. The sensitivity of I_{R_2}, I_O, and T to signals varies directly as a joint function of the frequency of past occurrence and signal strength.
2. The cells labelled LTM are long term storage elements responsible for the sensitivity of I_R and I_O.
3. The cell attached to I_{R_2} and labelled STM is a short term memory element for storing digits and has a rapid decay with time and some maximum capacity.
4. The cell labelled STM and attached to I_O is a short term memory element for storing partial sums.
5. The initial strength of the internal signal S_i varies directly as the strength of the external signal S_E and decreases with elapsed time.

This system is a relatively simple model that agrees to a considerable extent with the observed phenomenon and facilitates isolation of certain parameters as discussed in the next section. The system relates internal signal strength to the external stimulus and allows for a weakening of the signal if too much time is taken in transmission. Experience is a determining factor in this system. If "noise" is introduced into the system we then have the possibility of confused recognition due to: high noise level, weak signal, time delay, inexperience, or a combination of these. In passing it is noted that motivational differences in subjects might reflect different "noise" levels in the central nervous system, the highly motivated subjects having the lowest ratio of noise to signal strength.

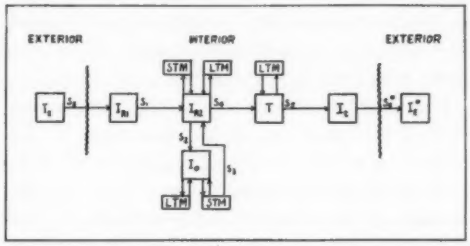

FIG. 4. Schematic diagram of a system which simulates the performance of simple addition. The units in sequence beginning at the left are: I_E, external information; S_E, external signal; I_{R_1}, information receptor; S_i, internal signal; I_{R_2}, information recognition unit; STM, short term memory unit; LTM, long term memory unit; I_o, operation unit or adder; T, transmitter activator; I_t, information transmitter; S_E*, new external signal and; I_E*, new external information.

MATHEMATICAL MODEL

Addition Time

The time required to add several digits can be separated into 3 general components: 1) the time required for the perception of the digits; 2) the time required for the addition of each digit to the partial sum of digits previously added: 3) the time required to write down the answer.

Component 3, the time required to write down the answer, will not change very much with n, the number of additions. For the range of n considered here, the sum can only be a 1, 2, or 3 digit answer. This component will be a very small part of the total time in problems of about 4 or more digits. We can take it to be a constant independent of n and will denote it by t_w. In the physical model, t_w is the time required for the passage of the signals S_3, S_4, S_E and for the operation of I_{R_2} (in recognizing S_3 and transmitting S_4), T, and I_t (fig. 4).

The time required for the perception of each

digit should be about the same for each digit regardless of its position in a series. In the model this perception time will be the time needed for the operation of I_{R1}, for the transmission of Signal S_1, and for the operation of I_{R2} in recognizing S_1. Letting t_s be the time needed to perceive any single digit, the total time for the sequential perception of $n+1$ digits will then be $(n+1)t_s$.

The addition of each succeeding digit to the sum of the preceding digits takes place in I_o, and its time will be the operation time of I_o plus transmission time of S_2. This process should require about the same amount of time (for each digit) for the first few digits. That is, for a short problem or for the first few digits of a long problem, we assume that there is a constant addition time, t_a. This might hold until n reaches some critical value, which we call n_o, but beyond this each addition in a sequence might require a longer time. The time, t_a, for short maximally familiar problems is primarily the result of some physiologic limit, whereas the longer time required as n increases might be expected to depend on the individual's experience with problems of this length. This experience could be expressed as a probability distribution giving the frequency with which the individual has encountered addition problems of any given length.

There is no direct evidence on the form of this distribution, but it must certainly be very highly skewed, long problems being much more infrequent in daily life than short. A simple form which has frequently been used for skewed distributions is the following form of Pareto's distribution,

$$\text{frequency, } N = \frac{A_o}{n^{1+k}}, \quad k > 0. \tag{6}$$

In particular, Zipf (17) has shown that a great variety of linguistic, economic, and sociologic data can be fitted at least approximately by this distribution. For the present application, we are concerned only with the tail of the distribution, since we have assumed that for small n, the addition time is fixed by a physiologic limit at a constant t_a.

If we now assume that the actual time required for the nth addition, when n is greater than n_o, is inversely proportional to its frequency in the experience of the individual, we can write this time as

$$t_a'(n) = Bn^{1+k}, \text{ for } n > n_o. \tag{7}$$

The total time $T(n)$ required for the completion of the addition problem of n operations will then be, when $n \leqq n_o$,

$$T(n) = t_w + (n+1)\, t_s + nt_a, \tag{8}$$

since there are n additions to be performed. This is, of course, linear in n, or

$$T(n) = A_1 + B_1 n, \text{ for } n \leqq n_o. \tag{9}$$

When n is greater than n_o, we will have for $T(n)$

$$T(n) = t_w + (n+1)\, t_s + (n_o)t_a + \sum_{i=n_o+1}^{n} t_a'(i)$$

$$= T(n_o) + (n - n_o)\, t_s + B \sum_{i=n_o+1}^{n} i^{1+k}. \tag{10}$$

The sum here can be evaluated with sufficient accuracy for our purpose by the first 2 terms of the Euler-Mac Laurin summation formula giving

$$\sum_{i=n_o+1}^{n} i^{1+k} = \frac{1}{2+k}\,(n^{2+k} - n_o^{2+k}) + \frac{1}{2}\,(n^{1+k} - n_o^{1+k}). \tag{11}$$

This summation is exact for $k = 0$, and k will always be small, so the error can be ignored.

So we finally have

$$T(n) = A_2 + B_2 n + Cn^{1+k} + Dn^{2+k}, \quad \text{for } n > n_o. \tag{12}$$

Equations *(9)* and *(12)* then give the dependence of $T(n)$ on n, which consists of a straight line portion up to n_0, and then a curve that is approximately parabolic. Of course, we cannot expect to observe a sharp break in the form of $T(n)$ at $n = n_0$. Even for a single individual this probably would not appear, and certainly when our observations are averages for a large number of individuals we must expect a gradual transition instead of any sudden change.

In the section on results the following equation was used to fit the relation between time and problem length:

$$T(n) = Kn^m. \qquad (1)$$

In the fitted curves the values of m were very close to unity or exceeded it, so that *(1)* gives an expression for time corresponding to the third term in *(12)*. The fact that the more complicated equations *(9)* and *(12)* were not needed to obtain a good fit could easily be explained by sampling errors and other sources of variation in the observed data. Certainly such curves could be fitted but hardly seem necessary if one looks at the data. One may then conclude that the observations are not in disagreement with the analysis of the time required for completing an addition problem which has been given here.

Accuracy of Addition

The possible sources for error in performing an addition can be analyzed into 4 components as follows: 1) errors in perception of the digits; 2) errors in the addition of a digit; 3) errors in carrying over the partial sum; 4) errors in writing down the answer.

When $n + 1$ digits are added there must be $n + 1$ perceptions if the problem is carried out, as usual, by adding one digit at a time. If we assume that the probability of correctly perceiving any one digit is the same as that for any other, and call this constant probability p_s, then the probability that all $n + 1$ will be correctly perceived is

$$P_s = p_s^{n+1}. \qquad (13)$$

The probability p_s is, in the physical model, the probability both that I_{R_1} operates correctly and that the signal S_1 is not distorted during transmission.

Some individuals add by groups of 2 or 3 digits instead of single digits. Let g be the number of digits in a group, then there must be n/g correct perceptions in order that no perceptual error is made. If the probability of any correct perception is now p_s', then the probability that all the groups will be correctly perceived is

$$P_s = p_s'^{n/g} = (p_s'^{1/g})^n, \qquad (14)$$

which is of the same form as *(13)*. This is not quite exact when n is not exactly divisible by g, but this small difference can be ignored for our purpose. Even if the grouping is not the same but varies slightly, g represents the average grouping and the resulting estimate of P_s closely approximates the actual P_s. Since the other components of the error can be treated in the same way, this means that we do not need separate considerations for individuals who add by groups of digits.

Now consider $p_n(n)$, the probability that the addition using the nth digit will be correct. p_n is the probability that S_2 is not distorted and that I_n carries out the addition operation correctly. In the process of learning to add this might be expected to follow the usual S-shaped type of learning curve as shown in figure 5, where the abscissa is the number of trials.

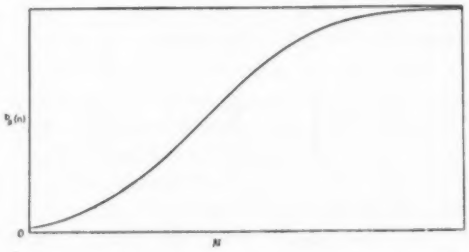

FIG. 5. Generalized learning curve illustrating the probability of a correct response, $P_n(n)$ as a function of the number of trials, N.

But in this case, the number of trials is just the frequency of use discussed in the previous section, and for which we adopted the distribution given by *(6)*. To arrive at an

expression for the dependence of $p_a(n)$ on n, we need a relation between $p_a(n)$ and N, frequency of use, and then we must eliminate N between this expression and *(6)*. Various equations have been fitted to learning curves, in particular the normal probability integral (4). The use of the normal probability integral (or any similar formula adequate to express a learning curve) and the Pareto distribution, would give a very complicated expression for the relation between $p_a(n)$ and n. This would be quite unsuitable for our purpose, because the available data are not sufficiently accurate. However, it is not hard to see that eliminating N between figure 5 and equation *(6)* would result in a relation of the form indicated in figure 6. This curve immediately suggests using

$$p_a(n) = p_{ao}e^{-an - bn^2}. \qquad (15)$$

This is general enough to fit most curves of the indicated form and is the expression which we will use.

The probability of all n additions being correct is

$$P_A = p_a(1)p_a(2) \ldots . p_a(n). \qquad (16)$$

Using equation (15) this gives

$$P_A = p_{oa}{}^n \exp\left\{-a\sum_{m=1}^{n} m - b\sum_{m=1}^{n} m^2\right\} = P_{oa}{}^n \exp\left\{-\frac{a}{2}n(n+1) - \frac{b}{6}n(n+1)(2n+1)\right\}$$

which could be written as

$$P_A = p_{oa}{}^n e^{-(A_1 n + A_2 n^2 + A_3 n^3)} \qquad (17)$$

with

$$A_1 = \frac{a}{2} + \frac{b}{6},\ A_2 = \frac{a}{2} + \frac{b}{2},\ A_3 = \frac{b}{3}.$$

The probability of correctly carrying over the partial sums will be the probability that the short-term memory unit STM, which is part of I_o, operates correctly. This probability should vary with n in the same way as p_a. However, there is an essential difference here in that a problem involving only 2 digits does not require any carry-over, the addition being performed with directly perceived digits. Thus the process of carry-over makes its appearance first in the 3 digit problem in trying to fit relations to the observed data on correct addition. If we actually assume probability of correct carry-over to vary with n, similar to correct addition, then we get a formula similar to *(17)*

$$P_c = p_{oc}{}^n - 1_{\bullet} - (B_1 n + B_2 n^2 + B_3 n^3) \text{ for } n \geq 2. \qquad (18)$$

The probability that the answer will be written down correctly can be assumed to be a constant P_W, independent of n. This involves the same parts at t_w and requires the correctness of S_3, S_4, S_5, S_E and I_{R2}, T, and I_t.

Finally the probability that the whole problem will be worked correctly will be

$$P(n) = P_S P_A P_C P_W = P_W p_s{}^{n+1} P_{oa}{}^n P_{oc}{}^{n-1} e^{-\left[(A_1+B_1)n+(A_2+B_2)n^2+(A_3+B_3)n^3\right]}$$

$$= P_0 e^{-(C_1 n + C_2 n^2 + C_3 n^3)}, \qquad (19)$$

where

$$P_o = P_W p_s p_{oc}{}^{-1},\ C_1 = A_1 + B_1 - \log_e(p_s p_{oa} p_{oc}),\ C_2 = A_2 + B_2,\ C_3 = A_3 + B_3.$$

It should be noticed that knowledge of P(n) will not permit determination of the 4 components of error since only the resulting product is actually observed. When expressions of the form of *(19)* were fitted to the data it was found that the C_3 term could be taken as zero and that even the C_2 term was of doubtful significance, although probably not zero.

Discussion

While we do not have enough information about our input and output to yield a thoroughly satisfying set of relations in the present study, we seem to have enough information to construct a plausible model to account for some of the observed changes in performance and to anticipate future issues and research.

Certain factors are characteristically employed to account for changes in the performance of the elderly, e. g., lack of practice or disuse of

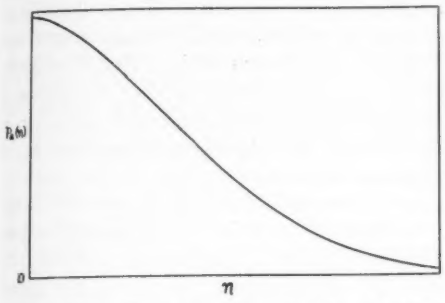

FIG. 6. Generalized curve illustrating the probability of a correct response, $P_a(n)$, in the addition operation using the nth digit in a series.

the skill, poor motivation, a slowed adopted tempo of work, greater task vigilance, poor perception of the task or problem, slow perception and/or slow reaction time. If the entire simulated system were unchanged with advancing age except for longer transmission time between units, the output of the system would suffer both in P and T by virtue of the decay of previous storage when making the combining operations of addition. The present data indicate that older individuals are relatively slowest for very short or easy problems, suggesting an age increase in the minimum time that the nervous system requires even for a very familiar operation. The time for all operations was longer in the elderly although the size of the time difference between the young and the elderly was reduced in the operations near the end of long problems.

There was no evidence in the present study that the elderly were adopting a slower work tempo to attain a maximum accuracy; their accuracy declined at a greater rate than the young when problem length was increased. If a slower work tempo or greater vigilance were important here, one would suspect that the elderly would show a greater increase in time as problems became longer and less decline in accuracy. Actually the converse was observed, i. e., the elderly increased their working time more slowly and their accuracy declined more rapidly than the young when problems were lengthened. The distinction must be made between a voluntarily adopted work tempo and a tempo determined by conditions beyond the control of the individual. The thesis here is that the slow tempo of the aged is not primarily a voluntary phenomenon, although there is reason to believe that to some extent an aged individual may slow his performance for compensatory purposes (14). The slower tempo of the aged results in less decrement than in young persons when the work period is extended (3), presumably because the elderly have greater time to dissipate any residual effects from previous operations.

The operation of simple addition is such a basic skill in daily living, almost as necessary as the spoken word, that one would suspect that in the elderly impairment of the skill would not be a simple disuse phenomenon. Some individuals may maximize their probability of correct answers by rereading the problem or repeating part of the cycle of events several times, for example, to avoid reversal of digits in a series. Welford and associates in their analysis of age and skill pointed out that the breakdown in skill with advancing age appears to be more a defect in, ". . . . organizing the incoming data and relating it to the relevant material . . . . than in availability of past experience itself" (14, p. 16). Thus, ". . . . incoming data function less efficiently, requiring, for instance, a stronger signal or more time than they did before" (14, p. 146). This certainly would suggest that the elderly would benefit more from problem repetition than the young or do relatively better on untimed tests. The Cambridge group would expect that any impairment of imput mechanisms would tend to produce less change in a skill or habit well established than in a relatively unfamiliar skill. This leads to the general hypothesis that, as one systematically varies problems from familiar to unfamiliar, the aged will show a greater decline in probability of correct responses.

Previous analysis shows that speed of writ-

ing (2) is correlated more highly with addition rate in the elderly than in the young (1). This correlation holds even when the proportion of time spent in writing an answer is small. Furthermore both speed and accuracy in addition were markedly impaired in the senile psychoses. In the latter cases at least, organic changes in the nervous system are highly correlated with a marked decline in speed of response. It seems that underlying both speed of writing and speed of addition is a common factor perhaps of a physiologic nature. An earlier study demonstrated a correlation between age and a mental speed factor (6); the speed factor was found to be represented in all the tests used.

With age there seems to be a reduction in the number of neurons (7, 10) which might be used in conducting or storing information (13). Loss of cells and possible altered function in the remaining fibers and synapses would significantly reduce the excitation that the environment may impart to the nervous system. With lower excitation one would expect a slower response.

The concepts used in the physical model or simulated system have drawn upon the principles of communication systems described by Shannon and Weaver (11) and also by Weiner (15) for other purposes. It is to be hoped future studies will permit a more rigorous analysis with a view toward linking the observed psychologic phenomena with the principles of the nervous system such as outlined by Rashevsky (9) and Landahl (8).

Summary

1. An analysis was made of the task of simple addition in relation to the length of the series of digits added, time T, probability of success P, and age of the subjects. Data were reported on 413 subjects in the age range 16 to 90 years inclusive. The subjects were required to add rapidly single columns of digits ranging in length from 2 to 25 digits.

2. The elderly subjects were slower for all lengths of problems and showed less accuracy with increased length of problem. The time required to add a series of digits as a function of problem length was described by the expression, $T(n) = Kn^m$, where $T(n)$ is the total time, n is the number of addition operations, and K and m are constants. The probability of success as a function of problem length was described by the expression, $P(n) = P_0e^{-an}$, where $P(n)$ is the probability of getting a problem of n addition operations correct, n is the number of addition operations, and P_0, a, and e are constants.

3. The empirical equations seem to be approximations to rational expressions derived from an analysis of the task of addition. By making certain assumptions about the nature of the task, the expression for addition time was developed, $T(n) = A + Bn + Cn^{1+K} + Dn^{2+K}$. The corresponding expression for accuracy of addition was $P(n) = P_0e^{-(C_1n + C_2n^2 + C_3n^3)}$. Within the limitations of the present data these expressions seem to be valid. Having 2 equations in terms of n, the number of addition operations, it is possible to express P as a function of T. A simulated physical system or model was described which incorporates assumed characteristics of the human subject doing addition.

4. There was no evidence that the elderly were adopting a slower work tempo to attain a maximum accuracy; their accuracy declined at a greater rate than the young when problem length was increased. It seems that the loss of speed of the elderly is a phenomenon basic to mental events and one intimately involved in aging of the nervous system.

The data reported in this study were gathered under the auspices of the Gerontology Section of the National Heart Institute and the Baltimore City Hospitals with the cooperation of the Baltimore City Schools, the U. S. Public Health Service Hospital of Baltimore, and the Fort Howard Veterans Administration Hospital, and with the assistance of Mrs. Charlotte Fox Rogers and Mr. Jack Botwinick. Use of the facilities of the Psychometric Laboratory of the University of Chicago in the analysis of the data is gratefully acknowledged.

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National Institute of Mental Health, Bethesda 14, Maryland, (Dr. Birren).

THE EFFECT OF AGE ON THE INCIDENTAL RELEARNING OF STAMP VALUES; THE USE OF DEDUCTION IN A SUBSIDIARY TEST

D. SPEAKMAN, M.A.

(From the Psychological Laboratory, The Nuffield Research Unit into Problems of Ageing, Cambridge, England)

EUROPEAN culture has, since antiquity, conceived of later life as a period when habits become rigid and change is almost impossible. It is perhaps natural, therefore, that this point of view has been reflected in one form or another in certain contemporary studies on the effect of age on learning tasks (1, 2, 3, 4, 5, 6, 7), and also perhaps in clinical studies which contain the observation that memories from many years past remain in patients who are apt to forget more recent events.

The opportunity occurred recently to test the hypothesis that older people are less able to modify their habits in an experiment which may at first sight seem trivial but which presented a task certainly not so regarded by the subjects and which was more realistic than most undertaken in the laboratory.

On May 3, 1951, the colours of many of the lower value British postage stamps in common use were redistributed, so that although the same colours were retained on the newer issues, the colour of each value with the exception of the 3d. stamp was changed. British stamp design has a conservative tradition, and the previous association between colours and values on the lower value stamps had continued without a break since 1912. The actual design on the face changed somewhat in content, but not appreciably in layout, over this period. The situation seemed to offer a unique opportunity to study the effect of age on the adaptation of stamp users to the new conditions and the degree to which incidental learning of the new issues had taken place. It would be expected, from the hypothesis mentioned above, that there would be fairly good knowledge of the old values among older people coupled with an inability to readapt themselves to the new values, and, consequently, less knowledge of them.

Submitted for publication October 13, 1953.

EXPERIMENTAL METHOD

Six stamps valued at ½d., 1d., 2½d., and 3d., were the basic material for this experiment. The numbers indicating the value were removed by means of a perforating punch, and the stamps were mounted on both sides of a piece of stiff card in the following manner:

First Side of Card

Number	1	2	3
Colour	Red	Green	Orange
New value	2½d.	1½d.	½d.
Old value	1d.	½d.	2d.

Second Side of Card

Number	4	5	6
Colour	Blue	Brown	Mauve
New value	1d.	2d.	3d.
Old value	2½d.	1½d.	3d.

Since the design for all stamps was identical, colour was the sole point of difference.

The round value discs clipped from both new and old stamps were mounted on a "clue card." There were thus 11 discs on the card, 2 colours for each value (except the 3d.), and 2 values for each colour (except the mauve)—the old value and the new one.

The use of the clue card requires some explanation. A subject could use it in either of two ways: he could either use it simply as an aid to memory, or he could, if he knew certain of the stamps, use it to deduce logically the values of the rest. In practice some 90 per cent of the sample were able to identify either

the old or new values of the red and green stamps; working on these two premises it was possible to deduce all the other values as follows: (a) If the old value of the red is 1d., then the new value of the red must be 2½d., and the new value of the blue must be 1d., and the old value 2½d. (the same information could have been deduced from knowledge of the old or the new value of the blue stamps); (b) If the old value of the green is ½d., the new value of the green must be 1½d., the new value of the orange must be ½d., the old value of the brown must be 1½d., the old value of the orange must be 2d., and the new brown also 2d. (the same information could have been deduced from knowledge of the old or the new values of either the orange or the brown stamps); (c) Since there is only 1 mauve 3d. disc, this stamp must have been the same in both old and new series. To subjects with a fair knowledge of either the new or the old values the process was considerably less complicated than this, since they had merely to identify the one value in each colour pair belonging to one series and, by elimination, the second member of the pair must belong to the other series. By contrast, subjects only knowing one or two of the new series and no old values had a more difficult task in identifying the new, since the process involved more than one deduction for each identification. The effect of this latter factor on the results is considered later.

The help of 80 subjects aged 20 to 86 was enlisted. Thirteen of these were dropped because 1 was a philatelist; 7 were office workers, club secretaries, and others using unusually large numbers of stamps; and the other 5 rarely mailed or received letters. The remaining 67 subjects in the different age groups were as equal as possible as regards cultural milieu, 28 of them being related to each other by blood or marriage. They were asked to state approximately how many stamps they used per week, whether they bought them singly or in sheet form or in books of stamps, and whether they thought they would recognize the difference between a 2½d. and a ½d. stamp by the colour. They were then shown the stimulus card and asked whether they could identify any of the stamps as in present day use. They were then reminded of the colour change, and asked whether they could state the values the stamps would have born before the change occurred. If the subject were able to identify all the stamps in the new series without difficulty, the experiment was then discontinued. If the subject failed to identify all the stamps in the new series he was told that he had failed to do so and was given the clue card. It was explained that the cuttings were from both new and old stamps and that for each colour there were 2 values, the old and the new, and that if correctly used, it should help in identifying the series correctly. From the responses and from the later questioning of the subjects it was ascertained whether they had used a process of deduction or not.

In order that subjects should be equated for exposure, all except 2 were tested during the week of January 21-28, 1953.

Results

The Recall of Old and New Values.—From the point of view that older people are less modifiable than younger it would be expected that the recall of the old values would show no decline with age but that the recall of the new values would decline markedly. The results in table 1 show that the reverse occurred. Recall scores for the old values fell off with age while scores for the recall of new values showed no consistent change. It would seem that as far as the ability to substitute one set of incidentally learned associations for another, older one, is concerned, there is no evidence here that older people are any less able to modify their behaviour than younger people, at least with the material used, and at the cultural level studied. Nor does the fact of the previous colour change in 1912 invalidate this general picture. Those subjects now in their 60's, 70's, and 80's would have been in their 20's, 30's, and 40's at this time: the apparent attainment of these subjects in the new series after eighteen months' exposure leads one to doubt that after 40 years to familiarize themselves with

TABLE 1. THE DISTRIBUTION OF SCORES FOR BOTH NEW AND OLD SERIES AS A FUNCTION OF AGE.

1. Results 'New' Series.

Age.	Number of People Having Score of: 0	1	2	3	4	5	6	Total	Average Score.
20-29	—	2	3	3	1	1	3	13	3.4
30-39	—	5	—	3	1	1	2	12	2.9
40-49	—	3	8	1	—	—	—	12	1.9
50-59	2	2	3	2	1	—	1	11	2.2
60-69	1	3	2	0	1	—	2	9	2.5
70-86	—	1	6	2	0	1	—	10	2.4

2. Results 'Old' Series.

Age.	Number of People Having Score of: 0	1	2	3	4	5	6	Total	Average Score.
20-29	—	—	—	2	—	6	5	13	4.8
30-39	—	—	1	1	2	4	4	12	4.7
40-49	—	—	—	3	5	2	2	12	4.3
50-59	—	1	3	4	2	—	1	11	3.0
60-69	1	3	1	2	1	—	1	9	2.3
70-86	2	1	2	3	2	—	—	10	2.2

3. Number of Persons Making Correct Score by Stamp: 'Old' and 'New' Series.

Age.	'New' Series. Red	Green	Orange	Blue	Brown	Mauve	'Old' Series. Red	Green	Orange	Blue	Brown	Mauve
20-29	10	7	6	8	6	7	11	12	12	11	12	6
30-39	10	8	5	5	3	4	11	12	9	10	10	5
40-49	8	9	—	2	1	3	12	11	7	7	7	6
50-59	5	7	4	3	3	2	9	10	7	5	2	1
60-69	5	3	4	2	4	5	5	8	2	3	1	2
70-86	9	7	4	1	2	1	6	7	1	4	3	1

Using the ranking method of Kendall (Tau), the following results indicate the amount of association between age and score:

All S's ranked by age range and score on 'new': N. D. = 1.41 $P < .2$
All S's ranked by age range and score on 'old': N. D. = 5.5 $P < .0001$
(both correlations are negative).

them, their scores on the old before the last change-over would have been much, if at all, less than that of those under 50.

The observation that a larger (but not significantly larger) number of those over 50 than under 50 scored better on the new series than on the old raised the question of whether remembering the new causes forgetting of the old. To test this, scores on the old and new were correlated (using Kendall's Tau) for ages 20 to 49, for ages 50 to 86, and for all age groups separately. In no case was a negative correlation observed such as would be expected on this hypothesis. The positive correlation (significant at the 2 per cent level) observed in the 20 to 49 group suggests that for this group scores on both were related to some common factor, such as, for example, general retentive ability.

The present data do not enable us to say why the results of this experiment should be so different from those of previous ones on learning and memory in relation to age, but there are several differences between the tasks presented by this and previous experiments, one of which might be sufficient to cause the discrepancy. For instance:

a) The time scale for the whole process is considerably longer than for any laboratory experiment. Not only does this mean that there

is a longer period for learning, but also for forgetting.

b) While the task is, like those of many previous experiments, an irrational one, it is, unlike those of previous experiments, a useful one.

c) Not only is the present task a non-motor one, it is very likely not even a verbal one until the time of recall.

Further experiments aimed at controlling these variables would seem to be worth while.

Recall with the Use of the Clue Card and the Use of Logical Analysis.—The scores after the introduction of the clue card are shown in table 2, and figure 1.

It can be seen from the table that the younger subjects benefit most from the clue card.

If the results are analysed in terms of the number of people in each age group who used a process of deduction, it is found that the proportion of people so doing tends to diminish slightly after 40, and more abruptly after 60, the number using logic after this age being negligible.

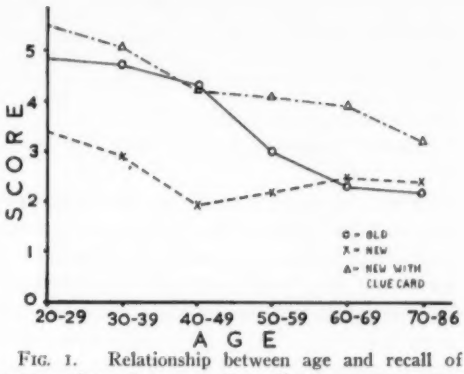

FIG. 1. Relationship between age and recall of stamp values. Scores on the ordinate are mean numbers recalled out of six.

TABLE 2. THE DISTRIBUTION OF SCORES ON THE NEW SERIES WHEN THE MATERIAL WAS REPRESENTED UNDER CONDITIONS PERMITTING DEDUCTIONS.

1. Results on 'New' Series with Clue Card, Including Perfect Scores of Table 1.

Age.	Number of People with Score of: 0	1	2	3	4	5	6	Total.	Average Score.	Actual Gain as % of Possible Gain.
20-29	—	—	—	—	2	3	8	13	5.5	81%
30-39	—	—	—	—	4	3	5	12	5.1	71%
40-49	—	—	1	4	3	—	4	12	4.2	56%
50-59	—	—	1	2	5	1	2	11	4.1	50%
60-69	—	—	1	3	2	1	2	9	3.9	40%
70-86	—	—	2	3	2	—	1	8	3.4	28%

Using the ranking method of Kendall (Tau), the following result was obtained, indicating the amount of association between age and score.

All S's ranked by age range and score: N. D. = 3.95 $P < .001$ (negative correlation).

2. Results on New Series with Clue Card after Removal of Situations Requiring More Complex Deductions. Analysed by Stamps, but Ommitting 3d. Mauve, Which All Subjects Identified.

	20's	30's	40's	50's	60's	70-86.
a) Users of Logic.						
Number	6	6	5	4	1	—
Total Possible Gains	16	17	15	13	4	—
Total Actual Gains	14	15	14	9	2	—
Actual as % of Possible	87%	88%	93%	69%	50%	—
b) Non-Users of Logic.						
Number	4	4	7	7	8	8
Total Possible Gains	12	11	22	16	22	15
Total Actual Gains	8	4	5	5	9	5
Actual as % of Possible	67%	36%	23%	31%	41%	35%

Age Groups

	20-29	30-39	40-49	50-59	60-69	70-86
Number given clue card	10	10	12	11	8	8
Number using clue card to make deductions	6	6	5	4	1	0

It may be objected that since the older subjects did not score so highly on the old values as did the younger, the type of deduction required of them would have been of the more complex variety described earlier and that therefore these figures do not give the true trend. Accordingly, the results were tabulated, omitting the few cases where a more complex process would have been required. It will be seen from table 2, section 2, that the efficiency of deduction among those subjects who used it tended to rise slightly until the forties but fell thereafter. In all age groups, the percentage of actual improvement over possible improvement is higher for the subject who used logic than for the subjects who did not.

From the comments and behaviour of the subjects, it seemed that the older people responded to the clue card in a different way from the younger. Thus while many of the younger subjects found logical analysis easier than trying to create order among a mass of partly remembered meanings, older subjects seemed to find it easier to pick out visually those colour-value bonds which seemed most "appropriate." The result was that whereas the younger people seemed to regard the clue card as a useful aid, many of those over 60 quite obviously regarded it as merely another complication in a problem that was already difficult enough. This was exemplified in an 83 year old woman who had made a reasonable score on identification of the stamps, but when she was shown the clue card, and its function had been explained to her, commented, "Now this is really difficult, I shall never be able to sort them all out."

Many older subjects tended to make judgments that "felt right," and then either tried to twist data to fit or to ignore data when they did not fit. Compare, for example, the comment of a 26 year old clerical worker who by logical deduction had identified the new value of the brown stamp as 2d. and who said with some surprise: "It doesn't look right, but it must be," with that of a 69 year old woman who identified the new value of the orange as 2d. and the old as ½d. (the reverse of the real position), having previously identified the modern green as 1½d., which was correct. When it was pointed out that this identification made two ½d's. in the old series, she retorted "You're not trying to tell me I'm wrong are you?" and she emphatically reiterated her previous response. Some three weeks later she approached the experimenter's wife in the street and, commenting on this experiment, mentioned this incident, and said "but I was right about it after all!"

It was also common for older people who did not use logic to identify two 2d's. or two 2½d's. in their response and seem to be unaware of it. If, and when, this was pointed out, it was in several cases rationalized into an apparently logical framework by the introduction of a "deus ex machina" of which the most frequent was "Of course, there are really two in circulation." Many of the older subjects in fact seemed to lack the ability to carry on significantly connected trains of thought of the type necessary to solve this problem; that is to say, later responses did not seem to be evolved in meaningful relation both to the immediate situation and to earlier responses, but seemed independent, in sole response to the immediate stimulus. In the case of 3 subjects over 50 who made partial attempts to solve the problem logically and then fell back on guess work, their failure seemed to be because of an inability to remember and apply their earlier responses in the later stages of the problem. Naturally under these conditions

cross checking becomes impossible. Had the subjects written down their answers, the results might have been different.

The decline in the use of logical analysis found here parallels that found by Allan (7), who gave his subjects sets of statements about political, moral, etc., issues. Some of these statements were incompatible, and those taking part were asked to eliminate these latter and to explain why they were incompatible. There were 2 age groups, those under 35 and those over 35. A tendency was found for the subjects in the older group to comment on the material from their experience instead of making deductions from the material itself.

It is not, of course, possible at present to say how far the apparent inability of the older subjects to use logical analysis would be general to all tasks. It may well be that, in actual life situations, logical deduction becomes a habit linked to certain familiar situations where its utility is proven, and it is not applied to unrelated or to novel contingencies, or to political or other material where sound premises are usually lacking, or are emotionally unacceptable.

Summary

Some experimental evidence exists which suggests that as people become older, habits, once formed, become progressively less modifiable. In order to examine this hypothesis, 67 subjects aged 20 to 87 were tested for knowledge of stamp values some twenty months after these values had been changed.

The results showed that whereas recall of the old values fell off steadily with age, no significant change with age could be seen on recall of the new values.

When the material was re-presented in such a way as to permit the making of deductions about the values, the younger subjects improved their recall scores to a greater extent than did the older subjects.

The use of logic in this subsidiary test seemed to decline markedly after 60 years of age.

Although situations apparently exist where present behaviour is more adversely affected by past experience among older subjects, the hypothesis that older people are less modifiable in their habits finds no support in the results of this experiment.

The author is indebted to Mr. A. T. Welford for the very considerable help and advice given during the preparation of this manuscript; to Mr. J. Szafran for working out the values of Kendall's Tau; and to all those people, too numerous to mention individually, who persuaded their relatives or friends to act as subjects.

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Downing Place, Cambridge, England.

AN EVALUATION OF PSYCHOLOGICAL EFFECTS OF SEX HORMONE ADMINISTRATION IN AGED WOMEN

II. RESULTS OF THERAPY AFTER EIGHTEEN MONTHS

BETTYE McDONALD CALDWELL, PH. D.

(From the Department of Neuropsychiatry and the Division of Gerontology, Washington University School of Medicine, St. Louis)

In assessing the value of any pharmacologic agent presumed to affect the ability of the organism to adjust to its environment, either physical or behavioral, a brief period of observation is not sufficient. Changes induced by a given pharmacotherapy may seem impressive when viewed from one point in time but may later be revealed as only transitory, with subsequent attenuation or even reversal of trends. Furthermore, curves of improvement which are not carried to their asymptote can be misleading in their implication of continued change at the same rate. Therefore, any complete appraisal must follow the subjects long enough to determine ceiling effects and to detect any possible deleterious consequences to the organism.

In the field of geriatrics many advances have been made in the direction of improvement of the physical functioning of older individuals with one or another type of pharmacotherapy. Prominent among these agents have been the sex hormones, described by many investigators as not only improving physical status but as also offering psychologic by-products of considerable value. It is, after all, not the physical change *per se* which is the goal of treatment but rather the potential for more effective daily living which may be a concomitant of such change.

Exploratory studies by Masters and Allen (3) and Masters and Magallon (4) with various programs of sex hormone therapy in aged women demonstrated that striking changes of a positive nature in the endometrium of the uterus could be detected. Kountz (2) reported that the activity of such hormones was not limited to the genital tract alone but that they also had a stimulating effect on the epithelial tissue of the mucuous membrane of the nose and caused improved vascularity of the skin. Although ward observations of the subjects suggested that there was accompanying improvement in terms of memory, alertness, and interest in and contact with the environment, no objective measures of these variables and no control data were available. Accordingly a special group of subjects was selected which could be studied both physiologically and psychologically over a long period of time.

In an earlier paper Caldwell and Watson (1) reported on this group after six months of therapy, giving the following as a summary of the most important findings:

> The results of this analysis show many favorable trends which may be identified in the experimental group. Intellectual functioning, although not uniformly at a higher level, does show some improvement in so far as ability to think and willingness to expend intellectual energy are concerned. Memory seems definitely enhanced, particularly in respect to meaningful and logical material. Over the six-month period the experimental group made distinct gains in the ability to learn new material, even when this required the breakup of old associations which had long held sway. In certain areas where there was no intellectual improvement in the treated group, there was less of the decline than would have been expected by virtue of the increase in age of the subjects between the two examinations. The control subjects showed no more changes in these areas than would have been expected on the basis of chance. (1, p. 243)

Despite the optimism reflected in that paragraph, everyone connected with the project believed that more information was needed regarding the permanence of any observed changes. That is, would the sex hormone therapy, when administered over relatively long periods of time to elderly women, show a curve of equal, increasing, or diminishing returns?

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The present report concerns itself with that question and presents data from a treatment and control group after 6, 12, and 18 months of the experimental procedure and again one year after cessation of treatment. Such an extended follow-up should permit fairly reliable conclusions regarding the merits of the hormones with respect to psychologic change.

Research Design

As the general design of this study has been described in detail elsewhere (1), a brief resume should suffice here. Thirty women, mean age 75, living in one ward of a city home for the aged, were given thorough physical and psychologic evaluations prior to being divided into 2 roughly matched groups. Although matching was based primarily upon gynecologic rather than psychologic criteria, the groups were not significantly different in initial intellectual ability or age. However, the subjects later designated as the treatment group did tend to be slightly older, having an average age of 76 as compared to 74 in the control group. Fifteen of the subjects were given placebo injections of sesame oil, and 13 received regular injections of various combinations of female sex hormones.[1] Basic medication throughout the experimental period was 2 mg. of estradiol benzoate per week, although after six months of therapy various amounts of progesterone and testosterone were also given. Two main types of endocrine treatment were in operation: during the first six months the dosages of the hormones were manipulated to produce uterine bleeding, while for the remainder of the experimental period such bleeding was prevented by adding testosterone to the medication in a ratio of 2 mg. of estradiol benzoate to 20 mg. of testosterone propionate.

A battery of psychologic tests was selected to measure changes in 3 areas of behavior: intellectual functioning, speed and flexibility of reaction, and relevant attitudes and interests. Selection of appropriate instruments was of necessity limited by the reduction in sensory acuity and the failure to correct for this (glasses, hearing aids) so frequently found in aged individuals of similar economic status. The earlier report (1) has given details regarding the selection of the instruments as well as results from each instrument in turn. The present report is concerned primarily with changes in the cognitive area, which seemed upon preliminary evaluation to be the most striking and most significant.

[1] As 1 subject died during the interval between the preliminary evaluation and the initiation of the treatment regimen and 1 refused to accept injections, the experimental group was unfortunately smaller than the control group throughout the study.

Results

In a longitudinal study with 2 groups accorded different treatment, the relevant variable is the pattern of change shown by each group. For each test or subtest in the battery, an analysis was made of the difference between the change shown by the experimental group (D_e) and that shown by the control group (D_c), using as the statistical technique the t test. With subjects in this age range followed for such a long period of time, improvement must not always be expected to show the form of positive increment in a given function. That is, a mere slowing down of the normal decline to be expected with increasing age could also represent improvement. An analysis based on the patterning of changes permits such an interpretation, with significant D_e minus D_c possible in 3 different forms: a gain in the experimental group greater than an equivalent gain the the controls, a gain in the treated subjects and a loss in the controls, or a greater loss in the controls than that appearing in the treated subjects. In all the data to follow, the base line (the zero line in the figures) represents the initial performance level of each group irrespective of absolute score. Thus, even if the 2 groups differed slightly in their performance at the time of the initial appraisal (which was frequently the case), their performance could nevertheless be equated in the sense that this was the point from which all future evaluations for each group should be made.

In figure 1 the results from the Wechsler-Bellevue Intelligence Scale are presented, considered both from the standpoint of total IQ's and weighted scores for the various subtests. A brief glance reveals that the pattern of change

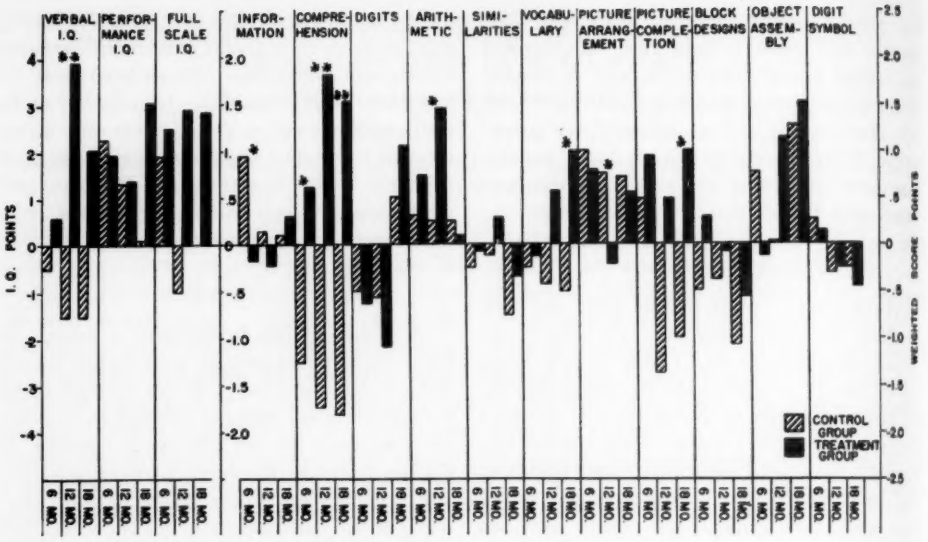

FIG. 1. Patterning of changes on Wechsler-Bellevue Intelligence Scale for experimental and control groups. Evaluations after 6, 12, and 18 months of therapy. The zero line represents the initial performance level of each group. Asterisks indicate significant between-group (D_e — D_c) changes at (*) .05 and (**) .01 levels of confidence.

for the experimental group tended to be positive, while that in the control group was almost randomly divided between positive and negative fluctuations. Thus, while a tendency toward continued deterioration was operating in both groups, this was combated to some extent in the control group by repeated exposure to the test and in the experimental group by the same practice effects plus the therapeutic agent. In all except 2 of the D_e-D_c comparisons which were statistically significant, the direction of change was in favor of the experimental group. These 2 reversals of predicted direction occurred on the Information and Picture Arrangement subtests, where at either the first or second retest the control group showed an increase in performance level and the experimental group a decline. By the end of the experimental period, however, this imbalance in favor of the untreated subjects had disappeared, with the 2 groups differing no more than would be expected on the basis of chance alone. In both Comprehension and Arithmetic, there was an absolutely greater difference after 12 months than after 18 months in favor of the treated subjects, whereas in Vocabulary and Picture Completion significant changes did not emerge until after 18 months of therapy.

In view of the relative unreliability of the subtests when considered in this fragmented fashion, it would be safer to evaluate the results from this instrument primarily in terms of the more comprehensive picture given on the left in the Verbal, Performance, and Full Scale IQ scores. Here it is readily observed that all the changes in the experimental group are positive, although the difference between the changes in the 2 groups is significant only on the Verbal IQ after one year of therapy. On the other hand, the control group showed decrements at all 3 evaluations on the Verbal Scale, increments on the Performance Scale (presumably more likely to reveal practice effects), and a balance of these 2 directionalities on the Full Scale, which combines data from the Verbal and Performance Scales. It is worthy of note that in this more summary representation, the maximum positive change in

the treated subjects was apparent after 12 months of therapy and that by 18 months a slight regression toward the original mean was observable.

Results from the Wechsler Memory Scale, as given in figure 2, highlight this trend even more impressively. On this instrument a follow-up examination one year after cessation of therapy was possible, which was approximately three years after the first evaluation. In total score

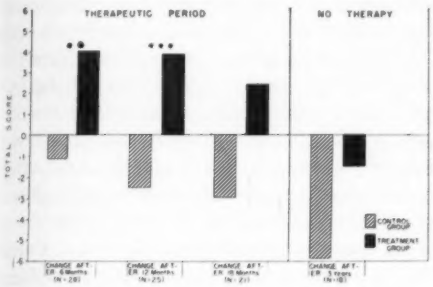

FIG. 2. Patterning of changes on Webster Memory Scale for experimental and control groups. Evaluations made after 6, 12, and 18 months of therapy, and after approximately 12 months following cessation of treatment. The zero line represents the initial performance level of each group. Asterisks indicate significant between-group ($D_e - D_c$) changes at (**) .01 and (***) .001 levels of confidence.

the control group followed a consistent downward progression, very much as would be expected from such a group of subjects between the ages of 74 and 77 years. In the treated subjects, on the other hand, there was positive change throughout the experimental period, with the difference between changes after 6 months significant at the .01 level and after 12 months at the .001 level. After 18 months the change, although in the predicted direction, was not statistically significant. In the post-therapy follow-up period, however, the treated group reversed its trend for the first time and performed at a level lower than that observed at the time of the initial evaluation three years earlier. This suggests that changes attributable to the hormones were not permanent and disappeared upon cessation of the therapy. Such a demonstration of the dependence of measurable changes upon continuance of the therapeutic substance gives clues to the nature of whatever modification actually occurred. That is, following certain types of therapeutic intervention (surgery, psychotherapy, etc.) it is anticipated that the introduced modifications, whether anatomic or psychologic, are conducive to sustaining a different type of adaptive response. From all indications, such is not the case with the present type of therapy.

As stated earlier, it was hypothesized that beneficial effects of the sex hormones would be observed both in terms of cognitive and affective functions of the treated subjects. However, contrary to expectation, there were few if any measurable changes in the emotional behavior of the subjects. The absence of such changes in the present study could mean either that no such measurable changes occurred or else that the instruments included to sample the affective sphere were not sensitive to such changes. Whichever explanation is correct, it was the subjective impression of the examiner that few gross emotional changes actually had taken place, at least with respect to such crucial variables as general mood, sociability, and tendencies toward increased group participation. This may well have been a function of the fact that the experimental subjects seemed, after treatment, to be in somewhat better contact with reality, and the environment with which they made this contact was not an especially rewarding one.

Such changes as could be detected seemed upon close analysis to fall primarily within the cognitive area. Many observed differences, however, fell short of statistical significance and offered only tantalizing leads. It was thus believed that some sort of composite picture of the results would demonstrate more conclusively whether these changes were genuine. Although the assortment of tests in the battery and their diversity of units prevented direct cumulative comparison, this difficulty could be circumvented by transforming all data to standard scores with arbitrarily equal means and standard deviations. There remained then the ques-

tion of which tests should be so compared.

The most outstanding changes which occurred seemed related in some fashion to underlying traits which might be called intellectual potential, flexibility of approach to problem situations, and motivation to succeed. A factor analysis would be the most satisfactory way of determining if 3 such underlying tendencies really exist and, if so, which items or tests most aptly measure them. However, the small number of cases and the known stratification of the sample (institutionalized women) did not seem to warrant such an attempt. A second alternative, which was actually followed, was to have experienced clinicians select, entirely on the basis of test rationale, those measures which should tell something about a subject's behavior in these areas. The complete list of subtests which went into each composite so selected is given elsewhere (1).

Figure 3 presents the results of the data analyzed in this fashion. As is readily apparent, in both intellectual potential and flexibility the

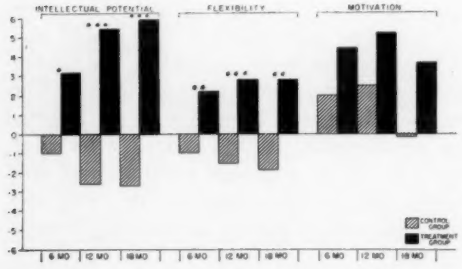

FIG. 3. Patterning of changes on composite standard scores of intellectual potential, flexibility, and motivation for treatment and control groups. Evaluations made after 6, 12, and 18 months of therapy. Asterisks indicate significant between-group ($D_e - D_c$) changes at (*) .05, (**) .01, and (***) .001 levels of confidence.

experimental group manifested a clear superiority over the untreated subjects throughout the experimental period, while in the motivation composite there were no significant differences in the pattern of changes. Although these figures may be interpreted as evidence of greater positive change in the experimental subjects, they may not be regarded as concrete evidence of the existence of 3 such determining tendencies, in view of correlations of .40 or better for scores in the 3 composites. This high degree of relationship suggests, in fact, that perhaps only one trait, reflecting in some way the ability of the subject to respond to intellectual challenges, has been really measured.

Thus far all results have been described in terms of group trends or averages. For the medical practitioner, however, a more relevant question is the determination of what he can expect from a specific patient placed on such a therapeutic program. Although prediction in terms of the group average may be the best and safest, statistically speaking, it may be quite unpredictive for an individual case. It was believed, therefore, that a glance at the range or spread of changes observed in both groups would give a better idea of how safe prediction based upon group data might be. From inspection of figure 4 it is apparent that for the 3 composite measures, dispersion of positive and

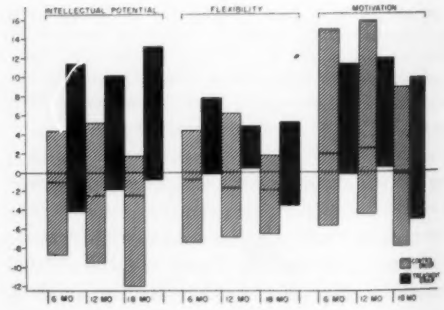

FIG. 4. Range of changes in experimental and control groups on composite standard scores of intellectual potential, flexibility, and motivation for experimental and control groups. The average change in each group is indicated by a line drawn across the bar at the appropriate point in the scale. The zero line represents no change from the initial test performance. Evaluations made after 6, 12, and 18 months of therapy.

negative changes was quite wide in both groups. For example, after six months of the procedure the control subjects had standard scores on the

intellectual potential composite ranging from −8.67 to +4.33, while in the experimental group the changes ranged from −4.17 to +11.50. It is equally apparent that, for the most part, differences from initial performance level in the experimental group tended to be positive in all 3 composites, while for the control subjects changes were about equally divided above and below the base line, with definitely more negative than positive change in the intellectual potential and flexibility composites. These figures caution the reader that, even when group trends are favorable, some treated subjects may well show a decrement in performance despite the therapy. These objective data on the individual differences in response to hormone therapy were amply supported by observations of ward behavior. Whereas a few treated subjects seemed to change their whole style of living while under the influence of the therapy, a few others continued to deteriorate steadily over the 3-year period.

Discussion

A word should be mentioned here about the meaningfulness of the obtained differences; statistical significance is not the only criterion by which to judge the relevance of increments or decrements in performance level of the treated subjects. For example, it is doubtful that some of the changes in the area of intellectual functioning are sufficiently large to signify discernible differences in everyday behavior in that particular area. This caution is not meant to imply, however, that one cannot extrapolate from significant changes in the criterion—performance on psychologic tests—to broader behavioral levels, but rather to remind the reader that such findings as improvement in memory and other intellectual activities do not herald revolutionary changes in the subjects' behavior. To be sure the obtained differences were significant but moderate; any claims made for the therapy should be correspondingly modest.

With respect to possible deleterious effects of the prolonged therapy, it can be stated definitively that there were no striking ones. No malignancies appeared; nor did any other serious illness which could in any way be attributed to the therapy. During the study 3 experimental subjects died as compared to 2 controls, while 1 subject had to be removed from each group because of non-cooperation. During the post-therapy period prior to the last follow-up, 2 experimental and 2 control subjects died. This death rate is no higher for either group than that customary for subjects of comparable age and physical condition in the hospital as a whole.

One final word should be said about the difficulty in maintaining adequate statistical controls in a longitudinal study of this sort where the number of cases is gradually decreasing. Between the first and last retest the size of the total group had diminished from 28 to 18, with the latter number hardly considered large enough for a statistically respectable study. However, in subjects falling within this age range a rather high attrition rate is inevitable. In view of the fact that changes, in order to be statistically significant, must be larger as groups become smaller, subjects who lived throughout the study may have maintained more significant changes than would be revealed due to the gradually diminishing number of cases. This, however, is speculative, and it would have been unwise indeed to abandon statistical measures at the conclusion of the study merely because the groups had been reduced in size. It would be desirable, however, in future studies to begin with sufficiently large groups so that this inevitable reduction in size of sample would not seriously limit the validity of the findings.

Summary

Follow-up data on a group of elderly women treated with sex hormones (estradiol benzoate, progesterone, and testosterone) for an 18-month period have been presented. Adequate controls were assured by having a comparable group of subjects given placebo injections. Over-all pattern of results tends to support the original hypothesis that improvements in intellectual functioning of the subjects will result from such treatment. Changes in emotional functioning, also predicted, were not detected. Within both dimensions there was wide varia-

bility in degree of response to the treatment.

Following only 6 months of therapy there were certain suggestive trends which were more striking after one year. After 18 months, however, some declines were apparent, suggesting that a ceiling had been reached after a year. Follow-up examination of both experimental and control subjects one year after cessation of the experimental regimen revealed that the induced changes are dependent upon continuation of the therapy and that no permanent modification of behavior potential ensues from temporary dosages of the hormones. These findings seem to warrant the interpretation that sex hormone therapy, as long as its limitations are recognized, deserves a place in the pharmacopoeia of the geriatric physician.

The writer wishes to express her appreciation to the various colleagues at the Washington University School of Medicine whose cooperation made completion of this study possible, especially Dr. Robert I. Watson, Dr. William B. Kountz, Dr. William A. Masters, and Mrs. Evelyn P. Mason.

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Present address, Department of Psychology, Northwestern University, Evanston, Illinois.

CURRENT SCIENTIFIC ACTIVITIES OF PSYCHOLOGISTS AS A FUNCTION OF AGE

WAYNE DENNIS, PH.D., AND EDWARD GIRDEN, PH.D.

(From the Department of Psychology, Brooklyn College)

IN an extensive and well-known series of studies Lehman (3) has related age to the production of outstanding works by eminent men in a variety of fields, including the sciences. His studies show that many more notable works of science are produced in the 30's and 40's than in other decades of life. However, little attention has been given to the relation between age and ordinary scientific activities in a *representative* group of scientific workers. The present report presents such an analysis in the field of psychology. The data to be related to age are the frequency of reading of a scientific journal and the rate of scientific publication among a random sample of the American Psychological Association.

Some of the material was derived from a recent study (2) dealing with the reading habits of psychologists. The nature of the obtained data permitted a further assessment concerning the role of age in reading. The data for the initial investigation and also for the present report were based upon a study of the readership of the *Psychological Bulletin*, one of the three official journals received by all members of the American Psychological Association.

The sample consisted of every tenth name in the 1951 Directory (1), which lists 8554 members. To each of the 856 persons thus chosen, a letter was sent requesting the recipient to indicate on an accompanying check-list those items of which he had read the major part. The check-list contained the *Bulletin* publications arranged under 5 categories: general articles, short articles and notes, special reviews, book reviews, and film reviews. The list contained a total of 59 items, all of which had appeared in the twelve months preceding the mailing of the poll on October 29, 1952. The check-list included all general articles, all special reviews, and all film reviews published during this period. It did not seem feasible to list all of the short articles, notes, and book reviews. In choosing items for the latter categories, we started with the most recent (September, 1952) issue of the *Bulletin* and worked backward until the desired number was obtained. No other type of selection of material was involved.

Of the 856 blanks which were mailed, over 50 per cent were returned by November 26, 1952. The poll was closed on that date because returns had practically ceased. Not all of those receiving the questionnaire (recipients) nor all of those returning it (respondents) could be used in the present analysis because the age of some subjects could not be determined from the 1951 APA Directory. In addition, since the number of persons in age-decades 70-79 and 80-89 was only 5, these respondents too have been excluded from consideration. (It might be mentioned that the readership level of these 5 people was exceedingly high). With these exclusions, the N's for the present report are 725 recipients and 397 respondents.

The percentage of Fellows among our recipients and respondents is not far from that given in the 1951 APA Directory. As shown in table 1, the sex-ratio in the returns is a close approximation of the sex-ratio among those to whom questionnaires were sent, differing only by a little more than 2 per cent. The percentage of recipients who supplied data in the different age groups varied between 49 per cent and 56 per cent. Thus there were no marked age differenees in responding to our request for data, although the lowest percentage of returns came from the oldest group.

The first analysis of the data for the pres-

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TABLE 1. ANALYSIS OF RECIPIENTS AND RESPONDENTS.

Age	Recipients N	Recipients % Males	Recipients % Fellows	Respondents N	Respondents % Responding	Respondents % Males	Respondents % Fellows
20-29	84	64	0	47	55	72	0
30-39	303	79	5	170	56	82	5
40-49	207	78	34	114	55	79	44
50-59	96	67	38	49	51	63	41
60-69	35	66	51	17	49	71	53
Total	725	74.8	19.3	397	54.8	77.3	21.9

ent report is concerned with the percentage of each age group of respondents who read one or more items in each of the categories of *Bulletin* articles. The breakdowns for the several categories of *Bulletin* articles by age decades are graphically portrayed in figure 1.

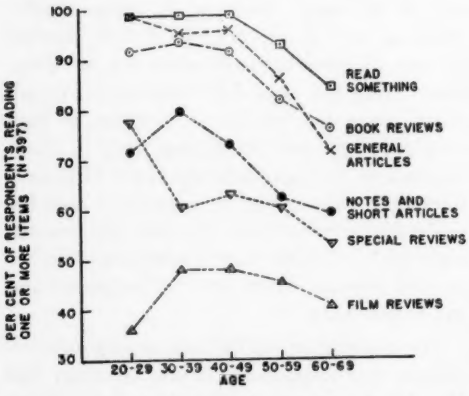

FIG. 1. Readership of the several categories of articles in the 1951-1952 issues of the *Psychological Bulletin* by a random sample of the 1951 APA membership.

With increasing age there is an appreciable drop in readership in all categories in terms of the percentage of respondents reading one or more items. The highest percentage of readership occurs in the age-decade 30-39 for 3 of the 5 categories. The high scores occurring in decade 20-29 are for special reviews and general articles. The greatest loss in readership occurred in general articles and the least loss in film reviews. It is to be noted that films were reviewed for the first time in the very latest issue of the *Bulletin* used in this study.

The *average* number of items and the *percentage* of items read per category was determined for each decade and summarized in table 2. There are differences between these scores and the statistics represented in figure 1, where marked losses with age are shown. In table 2, however, the total amount of reading remains surprisingly high and stable.[1] There is some over-all loss for all categories combined, a mean loss of 2.1 items, or 3.6 per cent from age 20-29 to 60-69. The largest loss is a drop in the mean of 1.8 items for general articles, a loss of 16.4 per cent. The average amount of readership would seem to be fairly stable throughout the age range tested, although there is a slight over-all decline.

Our study involves a cross-sectional sample at a given point in time. It lacks the dynamic characteristics of continued sampling at several successive decades in the lives of the same individuals. It is, of course, hazardous to infer from one to the other. This is particularly true because members elected some years ago (and now older) were required to meet different standards for membership than were those more recently elected.

There are large age differences in the ratio of Fellows to Associates. From age 20-29 through 60-69, the percentage of Fellows changes from zero to approximately 50 (table 1). An additional analysis of the data was made in order to determine if there were any important differences in level of readership between Fellows and Associate members of the APA. The small number of Fellows in the early decades makes it difficult to make comparisons at these age-levels. But, generally speaking, the Fellows equal or exceed the Associates in the same decade of life in both

[1] The authors wish to emphasize that they are in no way responsible for what to them was the surprisingly high readership of the *Bulletin*. The sample of materials used in the poll was taken from the period in which Lyle Lanier was editor. The present authors assumed their editorial capacities for the *Bulletin* in January, 1953. In so far as the results here reported are favorable to this journal, they must be attributed to the contributors and to the editorship of Lanier.

TABLE 2. MEAN NUMBER AND PERCENTAGE OF ITEMS READ PER CATEGORY BY DECADES.

Category	No. of Items		Age 20-29	Age 30-39	Age 40-49	Age 50-59	Age 60-69
Film Reviews	6	Mean No. of Items	0.9	1.3	1.2	1.2	0.9
		% of Items	15.0	21.7	20.0	20.0	15.0
Special Reviews	2	Mean No. of Items	1.1	0.8	0.8	0.8	0.6
		% of Items	55.0	40.0	40.0	40.0	30.0
Notes and Short Articles	10	Mean No. of Items	2.0	2.6	1.9	1.5	1.9
		% of Items	20.0	26.0	19.0	15.0	19.0
Book Reviews	30	Mean No. of Items	9.1	7.7	7.9	8.0	9.4
		% of Items	30.3	25.7	26.3	26.7	31.3
General Articles	11	Mean No. of Items	4.4	4.2	3.9	3.8	2.6
		% of Items	40.0	38.2	35.4	34.5	23.6
Totals	59	Mean No. of Items	17.5	16.6	15.7	15.3	15.4
		% of Items	29.7	28.1	26.6	25.9	26.1

The upper number in each box is the mean number of items read by a given age category. Thus, an average of 0.9 Film Reviews were read by the respondents in age group 20-29. The lower number in each box is the percentage of items read, obtained by dividing the mean by the number of items in the given category. Thus, the respondents in age groups 40-49 read a mean of 3.9 General Articles, which (divided by 11) is 35.4 per cent of the items in this category.

criteria of readership: the percentage reading one or more items as well as the mean number of items read in each category. It seems likely therefore that the higher reading activity of younger members reported in earlier sections is related to age rather than to a superiority of Associates over Fellows. There is no assurance, of course, in predicting the direction the scholarly level of younger members will take in the future.

We have also examined the relation between age and scientific productivity in this group. A count was made of the number of titles published in *Psychological Abstracts* during 1952 under the authorship of each member of our sample. This journal, of course, has a time lag, publications, on the whole, being abstracted some six to twelve months after they appear in print. By using the 1952 *Abstracts*, therefore, we have probably sampled studies published by our subjects during the time period referred to in our check-list with regard to readership. These data are summarized in table 3.

TABLE 3. TITLES IN 1952 PSYCHOLOGICAL ABSTRACTS PUBLISHED BY RESPONDENTS AND NON-RESPONDENTS.

	Non-Respondents			Respondents		
Decade	N	No. of Titles	Mean	N	No. of Titles	Mean
20-29	37	2	.05	47	16	.34
30-39	133	35	.26	170	76	.45
40-49	93	21	.23	114	57	.50
50-59	47	10	.21	49	13	.27
60-69	18	2	.11	17	4	.24
Total	328	70	.21	397	166	.42

It is conceivable that respondents to the ques-

tionnaire are in some way different from those who, for whatever reason, fail to respond. Since a check could be made in terms of the present criteria, a tally was made for respondents and non-respondents separately. It is of interest that at every age level, and for the group as a whole, the respondents published more by our criterion. The means for the respondents and non-respondents, respectively, are .42 and .21, exactly a 2 to 1 ratio.

Table 3 shows that members in the 30's and 40's in 1952 published more titles per person than did the younger or older psychologists. Doubtless, many psychologists in their 20's have not completed their training, a fact which operates against publication. The age differences are not inflated by titles of papers read at regional or national meetings. As indicated in the January issue of the 1952 *Psychological Abstracts*, no such titles have been listed since 1951. It is to be noted, however, that Lehman's data concerning papers read at meetings are similar to our findings regarding publications (4). A separate analysis (not shown) indicated that at each age level, the publication rate of Fellows somewhat exceeds that of Associates. Therefore, the lower publication records of the older groups, among whom the proportion of Fellows is greatest, would seem to be due to age rather than to membership status.

In psychology, as elsewhere, there is some tendency to believe that the newer recruits are not the scientific equal of the veterans of the profession. So far as the present scientific activities of different age groups are concerned, those who have more recently entered the profession are doing more reading and publishing (by our indices) than are their seniors. This difference, however, may be because of a decline with age rather than to a difference between generations of psychologists.

Summary

In a group of 856 persons randomly selected from the American Psychological Association, readership of a journal which is received by all members is in general higher among persons in their 20's and 30's than it is among older age groups, but age differences are not pronounced. Publication rates are highest in the 30's and 40's, but sexogenarians publish about half as much as the most productive group.

The fact that membership requirements have varied for different age groups makes interpretation of age differences difficult; we do not know whether the older groups are now less active than they were formerly or whether the newer recruits are a more active group than the older generation.

Grateful acknowledgment is made to the James McKeen Cattell Fund for a research grant defraying the expenses of the project of which this study is a part. We wish also to express our thanks for the assistance rendered by B. Goodman and E. Karcag.

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Brooklyn College, Brooklyn 10, New York.

VARIATIONS IN GRADUATE RECORD EXAMINATION PERFORMANCE BY AGE AND SEX

R. TRAVIS OSBORNE, PH.D., AND WILMA B. SANDERS, M.S.

(From the Guidance Center, University of Georgia, Athens)

FROM the literature (1, 3, 5, 6, 8, 11) there is meager evidence to refute the statistical fact that intelligence and achievement test scores as well as scientific and literary achievements decline with age. From the early investigations of Jones, Conrad, and Horn (3) to a recent paper by the present writers (6) the findings are substantially the same as those reported by Gilbert (1), ". . . there is a gradual decline in intelligence test scores from early to late maturity. . . . Intellectual decline is differential and largely a function of the test used, separate abilities apparently declining at different rates." Although lacking conclusive research verification, sex differences are also differential, so much so in fact that both Terman and Wechsler found it necessary to eliminate from their scales items which were "unfair" to one sex or the other. Evidence seems to indicate a superiority on the linguistic or verbal type item for girls while boys tend to excel on quantitative and mathematic items. These differences seem to hold for all ages up to the early twenties, beyond which level there is almost a complete lack of direct data. This investigation, subject to limitations inherent in a cross sectional study, is for the purpose of securing research evidence concerning the sex differences in rates of decline of acquired knowledge with age for young adults and more mature graduate students.

MATERIAL AND METHODS

The Graduate Record Examination was used for determining the student's level of acquired knowledge. This test according to the G.R.E. prospectus "is the only examination of national character which is expressly designed to measure achievement in the principal fields of collegiate study at the advanced level and which is endorsed or required by graduate and professional schools" (2). Actually the G.R.E. is a series of subject matter tests designed to cover broadly the main areas of the typical undergraduate program of instruction: mathematics, physics, chemistry, biologic sciences, social sciences, fine arts, and literature.

The 1807 graduate students who were in attendance at the University of Georgia between February, 1946, and February, 1952, were subjects for study. This group includes all graduate students except a few students who were not seeking an advanced degree. The 7 professional schools and the 5 divisions of the College of Arts and Sciences were represented. Men students out-numbered women 1173 to 634. The age range of subjects was from 19 to 65 with a mean of 31.76.

Figures 1 and 2 are histograms representing 3 point moving averages. Mean scores for women are shown by shaded bars; the comparable male averages are unshaded.

The number, mean, and standard deviation for the profile and average G.R.E. scores were determined for each 4 year age increment from 19 to 65; these are shown in tables 1 and 2. Not shown but available on request are tables of inter-age confidence levels of mean differences for the achievement test profiles.

RESULTS

From figure 1 it is seen that at every age level studied men exceed women in mean scores earned on the G.R.E. science profiles. Not all differences shown are statistically significant but many are at the .01 level. For mathematics, chemistry, and physics sex differences at all age levels are especially pronounced.

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TABLE 1. GRADUATE RECORD EXAMINATION PROFILE TEST SCORES FOR UNIVERSITY OF GEORGIA GRADUATE STUDENTS, BY AGE AND SEX

	Physics						Biologic Sciences					
	Males			Females			Males			Females		
Age Group	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.
19-22	61	55.68	8.39	71	45.84	8.28	61	56.38	10.46	71	52.96	7.47
23-26	303	54.45	8.39	110	44.72	7.42	303	54.36	9.37	110	50.25	7.82
27-30	270	53.52	9.57	84	44.31	9.09	270	53.23	9.20	84	48.09	8.05
31-34	156	53.53	8.17	60	43.85	8.92	156	50.09	9.83	60	48.26	9.25
35-38	125	52.54	9.35	80	44.81	9.14	124	48.75	9.43	80	44.10	9.20
39-42	77	50.81	9.30	78	43.09	8.49	77	46.68	9.20	78	44.71	8.05
43-46	44	53.69	9.68	54	42.32	8.76	44	47.92	10.23	54	44.05	10.46
47-50	25	52.54	6.29	29	41.48	8.12	25	46.08	6.09	29	41.50	10.46
51-54	12	45.90	9.52	22	39.88	7.37	12	42.14	11.90	22	39.44	7.24
55 up	5	52.54	6.45	17	38.37	7.47	5	46.54	9.31	17	39.71	9.66
	Chemistry						Mathematics					
	Males			Females			Males			Females		
Age Group	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.
19-22	59	56.97	10.19	69	46.64	9.01	37	51.97	8.39	54	47.42	9.57
23-26	295	54.18	10.43	105	46.10	7.82	243	52.82	9.68	96	46.72	10.00
27-30	245	52.89	9.19	81	44.40	9.32	223	52.03	10.11	65	46.67	8.55
31-34	147	52.27	8.94	55	44.83	8.76	102	50.62	10.75	44	46.16	10.16
35-38	105	50.36	8.45	70	43.53	8.01	94	53.38	10.81	49	44.99	13.12
39 42	70	50.81	8.82	72	44.62	7.89	63	49.44	9.89	55	45.72	8.87
43-46	38	51.76	9.50	50	44.64	8.32	31	52.19	11.72	37	43.54	9.95
47-50	25	54.33	9.32	28	43.61	7.64	19	51.09	9.95	22	44.21	9.73
51-54	12	45.39	10.43	21	43.32	6.71	12	54.39	10.59	13	45.84	6.83
55 up	4	48.50	5.40	17	43.20	5.22	4	57.53	4.46	10	38.98	9.84

[1] University of Georgia norms (N = 1716).

Thirty-one of the 40 comparisons show differences significant at the .01 level or better. Sex differences for biologic sciences are somewhat attenuated, but age differences are more apparent than on any of the other science profiles. In terms of percentages the biologic sciences loss with age from the youngest to the oldest group is 17 per cent for men and 25 per cent for women. Both curves fall off sharply with age increment after reaching a peak in the 19 to 22 age range.

The rate of decline in mean chemistry scores is greater for men than for women. In spite of this, the oldest group of men (55 and above) tested higher than the youngest women (19 to 22).

Men show no appreciable deterioration in mathematics with increased age; in fact, mean scores of several of the older groups exceeded those earned by the youngest (19 to 22) age group. The 3 point moving average (fig. 1) shows a slight but steady loss in mathematics for women, approximately 10 per cent from the youngest to the oldest group. For physics the rate of loss is approximately the same for both men and women averaging slightly over 1 per cent for each 4-year interval.

Mean achievement scores in literature and fine arts (fig. 2) hold up well for both sexes throughout the entire age range but, as expected, sex differences in these areas favor females. Over half of the 20 comparisons by sex yield CR's significant at the .05 level or better.

TABLE 2. GRADUATE RECORD EXAMINATION PROFILE TEST SCORES FOR UNIVERSITY OF GEORGIA GRADUATE STUDENTS, BY AGE AND SEX

	Social Sciences						Literature					
	Males			Females			Males			Females		
Age Group	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.
19-22	61	51.69	9.95	71	49.57	9.43	61	51.36	9.78	71	54.07	9.51
23-26	303	50.72	9.27	110	48.34	9.59	303	49.43	9.73	110	53.42	9.78
27-30	270	50.10	10.31	84	46.60	8.76	268	48.00	10.44	84	51.47	9.23
31-34	156	50.50	10.31	60	49.31	10.31	156	47.93	9.73	60	52.01	11.15
35-38	124	52.07	11.61	79	49.37	10.36	124	47.87	10.05	80	52.44	9.40
39-42	77	50.98	10.41	78	48.37	8.81	77	49.07	9.84	78	51.69	8.08
43-46	44	53.57	11.35	53	49.57	9.17	44	49.65	9.51	54	53.21	10.88
47-50	25	49.57	8.29	29	46.17	7.62	25	47.32	7.86	29	48.43	8.24
51-54	12	51.72	9.33	22	46.51	7.25	12	48.07	10.16	22	47.27	8.13
55 up	5	52.67	7.05	17	49.87	10.10	5	51.27	6.04	17	55.15	10.60

	Fine Arts						Total Averages of the 7 G. R. E. Profile Tests					
	Males			Females			Males			Females		
Age Group	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.	No.	Mean St. Sc.[1]	S. D.
19-22	61	50.85	10.65	71	54.77	10.25	57	53.16	10.65	68	50.35	9.25
23-26	301	49.97	9.75	109	53.78	9.90	293	52.03	10.25	107	49.30	9.05
27-30	260	48.98	10.30	83	50.25	8.94	258	51.09	10.65	81	47.72	8.89
31-34	151	47.59	9.85	60	53.61	10.20	149	50.29	10.25	57	48.63	9.55
35-38	122	46.78	9.30	80	52.90	9.65	117	50.10	10.35	74	47.93	9.05
39-42	74	47.18	10.40	78	50.61	8.29	74	49.34	9.80	74	47.36	8.09
43-46	42	50.56	9.90	54	52.63	8.99	41	51.20	10.20	51	47.65	9.10
47-50	24	41.68	6.58	29	47.53	7.84	24	48.90	9.50	28	45.24	8.19
51-54	11	45.12	8.04	22	50.83	8.34	12	48.00	10.15	21	45.17	7.39
55 up	5	48.50	2.46	17	53.59	10.35	5	50.91	7.34	16	46.42	9.30

[1] University of Georgia norms (N = 1716).

Although men consistently test higher than women on the social sciences profile (fig. 2) the differences are not significant nor is there an apparent trend in age differences. That is, men and women at all age levels studied seem to be homogeneous with respect to the knowledge and information called for on the social sciences profile test.

When all Graduate Record Examination profiles are averaged and the age-scores plotted (fig. 2) the resulting smoothed curves are similar to Wechsler's curve of mental growth and decline (12). The curves for average G.R.E. scores of men and women are parallel, with men exceeding women at all age levels by 5 or 6 per cent. Mean scores for both men and women fall off at approximately the same rate for each 4-year age increment.

DISCUSSION

The primary purpose of this study was to examine sex and age variations in performance on the Graduate Record Examination. There is ample evidence (4, 7) of reliable sex differences in achievement test scores at childhood and adolescent ages but it has been generally assumed that these differences are less marked for adults. In one of the very few previous studies using adult achievement test results Weisenberg (13) concluded that sex differences on test performance were negligible. His conclusions, however, were based on comparisons

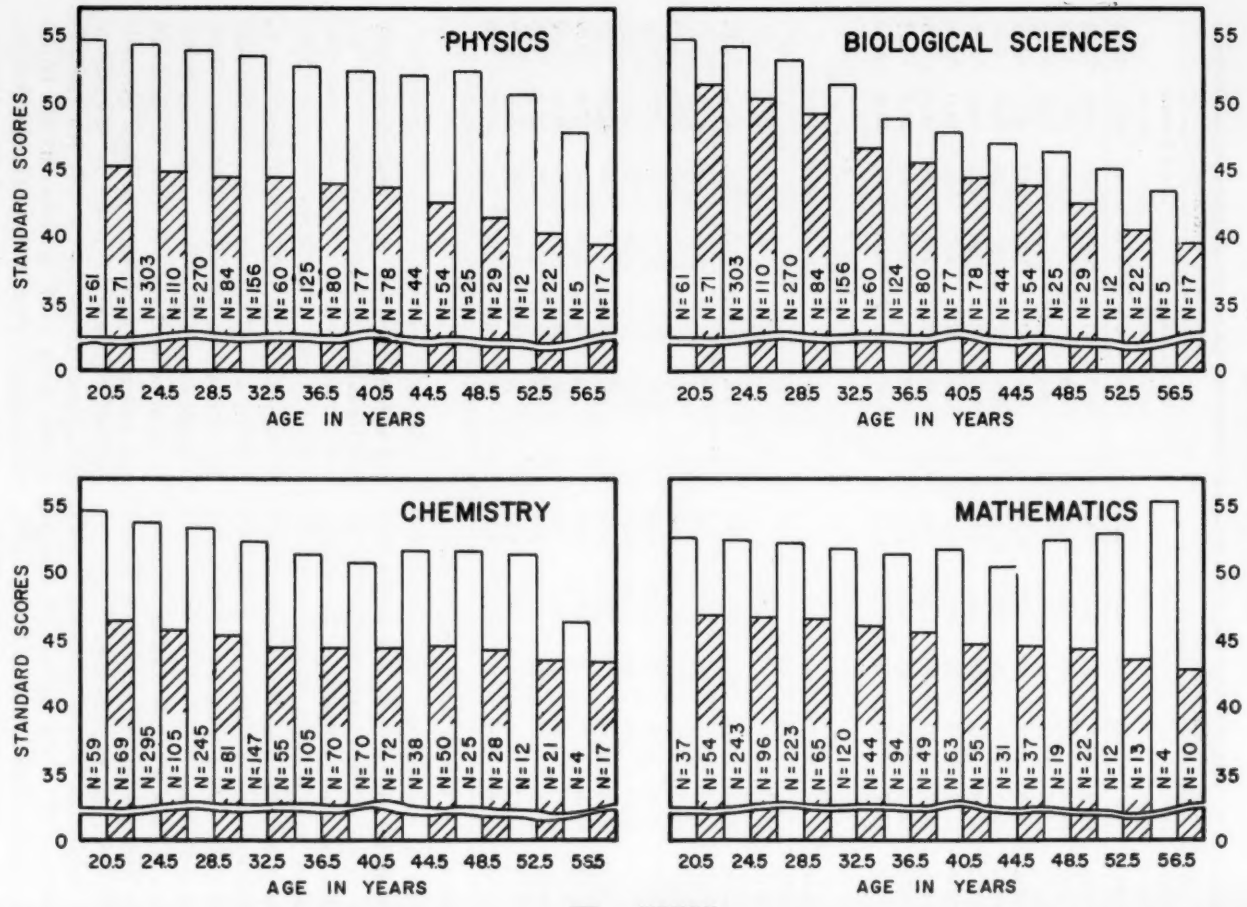

FIG. 1. Smoothed curves showing variations in G. R. E. performance by age and sex in physics, biologic sciences, chemistry and mathematics.

AGE IN YEARS

AGE IN YEARS

WOMEN
MEN

FIG. 1. Smoothed curves showing variations in G. R. E. performance by age and sex in physics, biologic sciences, chemistry and mathematics.

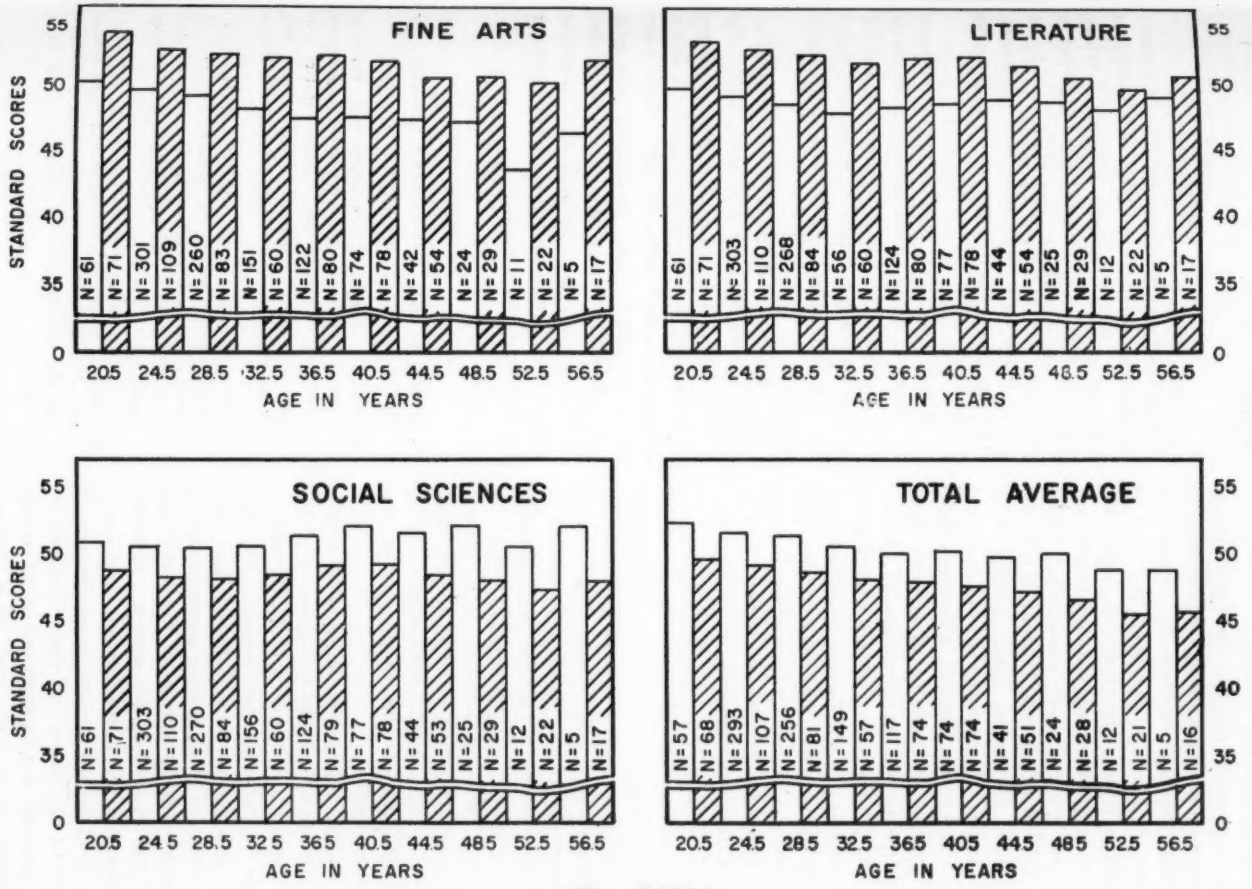

FIG. 2. Smoothed curves showing variations in G. R. E. performance by age and sex in the fine arts, literature, social sciences, and the total average of all profiles.

made "between all females rather than between the groups at short age periods."

There are several possible interpretations of the findings presented above. Differences in curriculum emphasis undoubtedly account for some sex variations in achievement found at the graduate level. This, however, leaves unexplained why the same sex differences appearing in mature graduate students are found consistently in grade school pupils before the differentiated curriculum could possibly have been a factor. Environmental, cultural, and even possibly some biologic differences have been suggested as operating to produce these significant statistical sex differences in achievement (9). Terman (10) believes variations in achievement by sex may be due to motivational causes and limitation of opportunity rather than lack of ability. Gilbert (1) suggests the same reason, lack of sustained motivation, to explain declining achievements with advancing age.

Other explanations may occur to the reader such as, for example, variations in professional interest and area of specialization. The differential growth of a field of knowledge rather than the age of the subject has been offered to explain performance variations in achievement. This as well as interest variability would be extremely difficult to evaluate. It is obvious that the statistical weakness of a cross sectional study of this type through significant sampling errors could account for all or part of the differences shown.

The findings reported in the previous section would seem to support the hypothesis of a differential rate of decline of acquired knowledge with age for both men and women. The rate of loss with age varies both by sex and subject matter area. The science age-score curves show losses ranging from 0 to 17 per cent for men to 7 to 25 per cent for women. Achievement scores in literature, fine arts, and social sciences hold up well for both sexes throughout the 19 to 65 age range. As these variations in performance are largely functions of the nature and content of the tests used, these findings should not necessarily be expected to hold for different tests, other age groups, or for any individual student.

Summary

The results of the Graduate Record Examination administered to 1807 University of Georgia graduate students between February, 1946, and February, 1952, were analyzed by age, sex, and subject matter profile. In the group there were 1173 men and 634 women. The age range was from 19 to 65 with a mean of 31.76.

At every age level studied men were found to exceed women in mean scores earned on the G.R.E. science profiles. In literature and fine arts women were superior; men were higher but not significantly so on the social science profile.

Sex differences in the rates of decline of acquired knowledge with age were noted. The rate of decline in chemistry is greater for men than women; men show no appreciable loss in mathematics with increased age. Mean scores in the humanities hold up well for both sexes throughout the entire age range. The data seem to support the hypothesis of a differential rate of decline of acquired knowledge with age for both men and women.

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University of Georgia, Athens, Georgia.

MORTALITY AND MORBIDITY STATISTICS
I. LIMITATIONS OF APPROACHES TO RATES OF AGING

DEAN F. DAVIES, PH.D., M.D.

(From the Hypertension Division, Department of Internal Medicine, Washington University School of Medicine, Saint Louis)

FOR at least a hundred and twenty-five years man has been asking himself how fast he is aging at different periods in his life. Does he age rapidly at first and then level off or does the rate of aging increase with increasing years? Perhaps his vitality is lost at a constant rate from the time he reaches adulthood. In order to answer this question a number of approaches have been made. This paper will discuss some of the difficulties which have been encountered in attacking this problem and their partial solution. The arguments and fallacies of these approaches are outlined in table 1.

MORTALITY STATISTICS

Perhaps the first approach to this question was an analysis of mortality statistics. Gompertz published an article (7) in 1825 in which he examined statistics on mortality rates which he and others had gathered. By plotting the death rate against age he found that the mortality rate curve thus obtained followed a geometric progression and that this shape "pervades in an approximate degree, large portions of different tables of mortality." He called this the "law of human mortality" and made interpretations of it which would bear on the question of how rapidly man ages. He concluded that the geometric increase in the mortality rate resulted from a progressive decrease in vitality with age and assumed that this was due to a progressive accumulation of the products of metabolism. The shape of this curve has not changed materially in over a century and is shown in figure 1 for women in the United States in 1940.

Others (1, 2, 14) have also used mortality statistics to draw interpretations of the rate curve of the process of aging. Bernstein (1), in discussing the formal laws of growth and decay, rejects the formula of Gompertz as modified by Makeham:

$$m_x = A + Bc^{x^c},$$

where m is mortality at age x and A, B, and c are constants.

Nevertheless, he accepts the fundamental concept of Gompertz and states, "the fact that a formula with only three essential constants fits such extensive data must have a biological reason."

Brody (2) states that mortality data on man seem suitable for measuring the course of senescence. He says, "it seems reasonable to assume, that other conditions being the same, the greater the degree of senescence, the greater would be the chances of breaking down of some

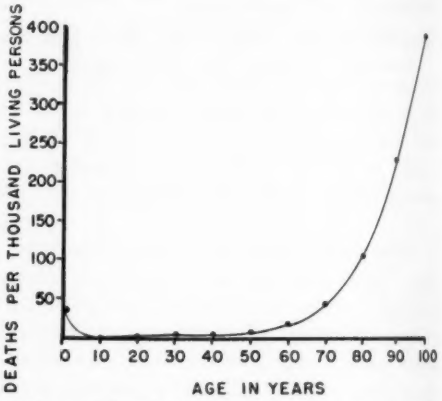

FIG. 1. Mortality rate curve for white women, 1939-41. Many authors attribute biologic significance to the shape of this curve. See text. Data from Sixteenth Census of the United States: 1940, Greville, T.N.E., Washington, U. S. Government Printing Office, 1946.

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TABLE 1. LIMITATIONS OF ASSUMPTIONS USED IN CONSTRUCTION OF CURVES ON RATES OF AGING.

	MORTALITY STATISTICS	CROSS-SECTIONAL DATA	LONGITUDINAL DATA
ARGUMENT	Exponential shape of mortality rate reflects changes in individuals.	Plot of the level of functions of different people at all ages indicates the shape of the aging curve for the race.	Plot of a sample of individuals at successive ages indicates their true rate of aging.
FALLACIES	(1) Assumption that the number of people dying at any age is related to degree of health of those alive at that age may be false.	(2) Curve formed by joining levels of functions of different individuals may not represent the shape curve to be found in any individual or group of individuals (See Fig. 4)	
	(3) In each case two independent variables are changing: age and quality or degree of heterogeneity of the population being sampled. (See text.)		
	(4) The aging curve is composed of inherent and environmental factors. The true or inherent aging curve cannot be isolated from changes of extrinsic or environmental origin.		

vital organ-system due to a given unfavorable exposure. The course of mortality under such conditions should therefore form an index of the course of senescence." He then proceeds to interpret the geometric progression in mortality rate in terms of the degree of senescence in man. He states, "the degree of vitality or of senescence (defining vitality as the reciprocal of senescence) at any moment is . . . a constant percentage of the degree of vitality or senescence of the preceding moment."

Pearl (14), in discussing specific death rates, substitutes the term "force of mortality" for the death rate. He concludes from the curves of age and sex specific death rates that the force of mortality is highest at the extreme ends of life. He answers the problem of the rate of aging in man by stating that the force of mortality is continually increasing at a nearly constant rate of increase. This would result in an exponential curve.

First Fallacy.—There are three limitations in this approach to the problem. They are self-evident to some but have been ignored by others. One fallacy of interpretation will be mentioned now; the other limitations will be discussed later. In the interpretation of mortality statistics in terms of the aging process in man a large assumption is made which is usually overlooked. The mortality rate curve shows the *number* of people dying per unit number living plotted against age. The assumption made by each of the authors quoted above was that the vitality or resistance to death of an average individual is proportional to his probability of dying as estimated from the incidence of death among people of the same age. While this may be a valid assumption, it does not necessarily follow. It is conceivable that every man might have an ever increasing resistance to death until the year or even the day of his death at which time it would show a precipitous fall. Thus, the curve taken as a reflection of physiologic age in the hypothetical average man is actually a plot of the proportion of men in any year who die. It tells nothing about the state of health of those who remain living. Vigorous men who die after a small thrombus forms in a vital organ give the impression of exemplifying one alternative. Others seem to be old before their time yet live into old age. The picture of waning vitality is characteristic enough of the later years to make it seem plausible that the rate of aging on the average is proportional to the mortality rate curve. The shape of the probability of

death curve, however, may be unrelated to the theoretic curve of physiologic age not only in the individual but in the average person as well. The curve describing man's vitality or physiologic age at progressive ages is yet to be drawn.

Cross-Sectional Data

The fallacy in the assumption, made first by Gompertz and frequently restated, of a relationship between death and physiologic age can be avoided by measuring specific physiologic functions. The simplest way of doing this is to study persons at different ages and join the average levels of function in a smooth curve. This has been probably the most common approach to the problem. Its advantage is that it plots functional level rather than incidence. Figure 2 is a hypothetical scatter diagram illustrating how such data might be plotted.

The use of this method generally confirms the suspicion that the curve connecting levels of each function of young adults with those of advanced age are not exponential as in the mortality rate curve (3); in general they are fairly straight. This is true, for example, with re-

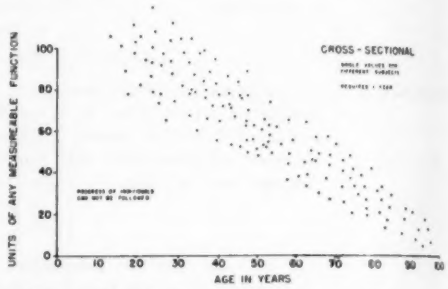

Fig. 2. Hypothetic analysis of the aging process. Cross-sectional data. The assumption from these cross-sectional data that the typical aging process of individuals is a steady decline may not be valid. See text.

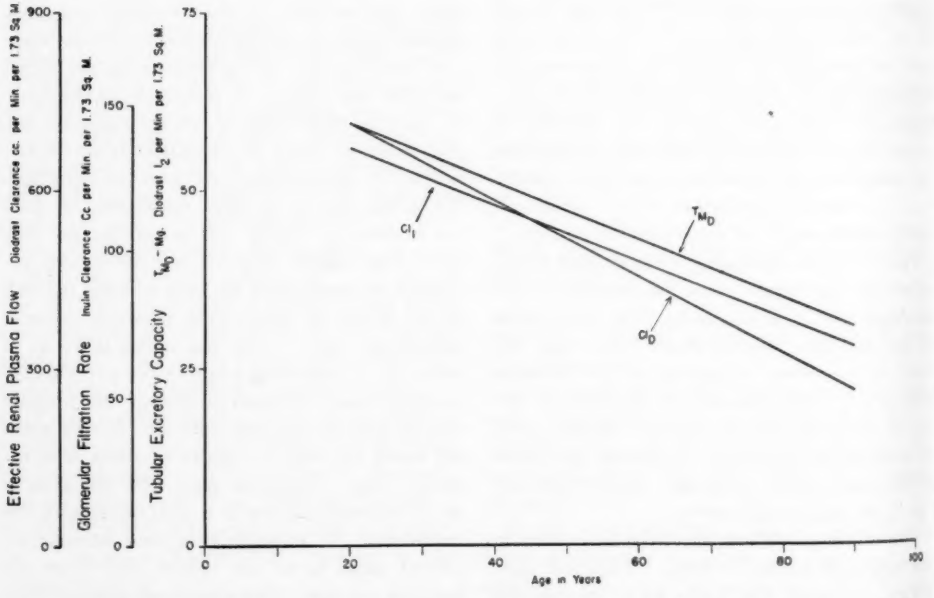

Fig. 3. Cross-sectional data. Straight lines of best fit, previously unpublished, derived from data on renal function between ages 20 and 90 in men (4). Cl_D, diodrast clearance estimating effective renal plasma flow (ERPF); Cl_I, inulin clearance, measuring glomerular filtration rate (GFR); Tm_D, tubular excretory capacity of diodrast. ERPF has a regression rate of 0.91 per cent per year; GFR, 0.72 per cent per year; and Tm_D 0.68 per cent per year. Regression rates calculated on basis of age 20.

gard to kidney function (4, 12), 17-ketosteroid excretion (10), gastric acid output (15), spleen weight (11), and other organ weights and measurements (16). Functions plotted in this way against age often form a straight line over a wide area of adult life. For example, cross-sectional data on blood flow through the kidneys of adults at successive ages have been found to fall off on the average by decrements of 0.96 ml. per minute every year between 20 and 90 years of age (fig. 3), a straight line being the only simple curve obtainable for the data. The fallacy of linking susceptibility to death or physiologic age with number of people dying has been pointed out. On the face of it cross-sectional data should give a satisfactory picture of the course taken by the aging process.

Second Fallacy.—There are two limitations to this reasoning which apply equally well to the discussion of the mortality rate curve. Again, one will be discussed now, the other later. The fallacy of interpreting cross-sectional data in terms of individuals is again an assumption which may or may not be valid. It is obvious to the most casual observer that the average values, while they may make a curve representing a hypothetic "average man," may also be only a composite of widely differing shapes of curves and not represent any individual or group of individuals. Figure 4 shows in an exaggerated and highly oversimplified way how a generalization about rates of aging in man might be grossly erroneous if based on cross-sectional data alone. The figure shows a straight line which represents the average of 3 grossly dissimilar component individuals or groups of people. While this is unlikely it points out the inadequacy of generalizations made about the nature of the aging process. Similarly, the exponential shape of the mortality rate curve discussed above depends on the variability of people's life spans. The curve of figure 1 would not be typical of that obtained for pure strains of inbred mice. In a carefully controlled environment the life span of such mice would be almost identical. Their mortality rate would be low and then rise very abruptly, but their physiologic age curve might be straight. This is a crucial point in the argument. While the upper and lower limits of the scatter at each age indicate the range compatible with life, the knowledge gained about the shape of the aging curve is minimal.

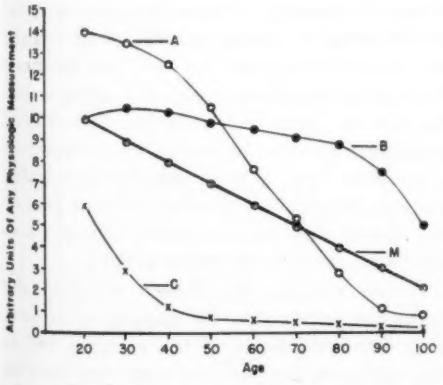

FIG. 4. Hypothetic curves showing how mean values of cross-sectional data may not reflect the shape of the aging process in any individual or group of individuals. Curve M is mean of curves A, B, and C which represent exaggerated examples of possible aging processes in different constitutional types within the species.

LONGITUDINAL DATA

An obvious answer would seem to be to plot data longitudinally. Here individuals are followed for a lifetime. While cross-sectional data, if representative, show the average range for the species at different ages, longitudinal data should demonstrate how the species is in turn composed of a continuum of subtypes. A hypothetical case has been discussed (fig. 4) to demonstrate the possible heterogeneity of the aging process in individuals showing none of the individual processes to be comparable in any respect to the average curve. However, the number of alternative types of curves are numerous and the one represented in figure 5 is the situation in which the curves are nearly parallel. In this case the higher the function at any age the more likelihood of death. Unless such a relationship is demonstrable from clinical experience it may not be recognized. Thus, it has been only by statistical demonstra-

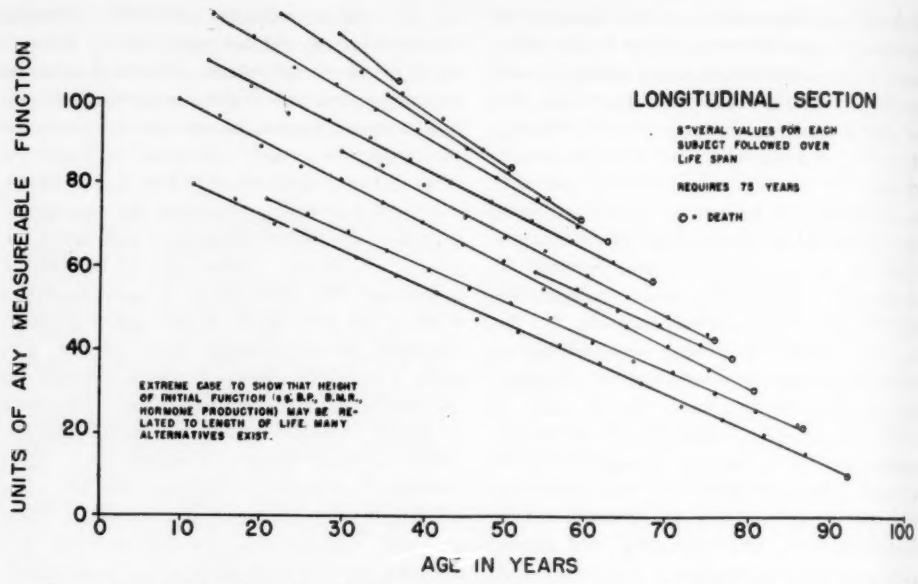

FIG. 5. Longitudinal data. Hypothetic analysis of the aging process in which one of many possible relationships is demonstrated, viz., a parallel decline of function in which the higher function at any age is the one most often associated with death. See text.

tion that full recognition has been given the association of increased weight with early death. Society still considers moderate obesity as a sign of health. Collection of longitudinal data, therefore, may demonstrate that, while the decline of a function with age found in cross-sectional data suggests deterioration with age, such a decline may also be evidence of resistance to the development of a condition, e.g., obesity, with a poor prognosis. This leads to the discussion of the third fallacy, one inherent in all three methods of answering the original question.

Third Fallacy.—Obviously there are differences within the species which account for the different lengths of life span. The curves in figure 4 may be expressed as heterogeneity within homogeneity. At the species level all the individuals are homogeneous with respect to the definition of the species, but the individuals differ in many characteristics including those of life span and of any measure of physiologic age. They are heterogeneous in that sense. Individuals acquiring a specific disease may be considered to be members of a subtype, being homogeneous in so far as they have a disease in common. Each group has a number of things in common including an average life span differing more or less from the mean life span of each other type. It is obvious that the loss by death of certain members of the population distorts the results by necessitating a sampling from a progressively more homogeneous group. This loss by death of part of the sample was disregarded in figures 1-4 in the discussion of cross-sectional data.

If we assume that these subtypes exist throughout adult life, the population in early adult life consists of all the subtypes and at the maximum limit of life span they have all run their expected course. Those falling in the tail of the distribution curve, i.e., the longest-lived subtype, are the last to die. They have at least one thing in common; they are homogeneous as to life span. They are probably relatively homogeneous as to the causes

of their long life spans. At the other end of the age scale such is not the case. Of a cross-section of the population, some have the predisposition to an early demise. Others will outlive their contemporaries. The older samples differs from the younger not only in age; it differs in composition as well. It is a highly selected population. Therefore any curve derived from an age span in which death occurs does not fulfill the requirements of a controlled experiment. Its shape in both cross-sectional and longitudinal data cannot be interpreted as representing the aging process of man since there are two independent variables: age and degree of heterogeneity.

Fourth Fallacy. Inherent Factors.—Before proceeding further, the initial question should be restated. Implied in the query into man's rate of aging is a desire to examine the inherent rate of aging uncomplicated by environmental factors. That hereditary environmental influences cannot easily be resolved is a truism. Deaths due to infection, automobile and other accidents, and during childbirth and infancy are primarily of environmental origin. Nevertheless, this stumbling block has been almost completely neglected in the literature and is a fourth fallacy in the argument that there is a relationship between mortality statistics and the inherent aging process. It also applies to a certain extent in both cross-sectional and longitudinal studies.

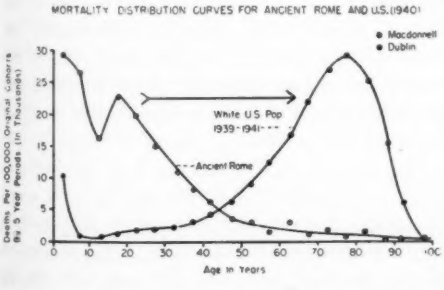

FIG. 6. Estimated frequency distribution of mortality in ancient Rome (13) compared with that of modern times (6). There is no evidence of a change in the maximum life span in spite of a marked shift of the mean and mode to the right. The change in the shape of the curves is chiefly a result of better control over diseases of extrinsic origin.

Figure 6 shows that the mortality distribution curves of ancient Roman and modern times are quite dissimilar. The difference in the curves is almost entirely explainable by changes in environmental influences. The mean life span of ancient Roman times was about 20 years, (13) endemic and epidemic infectious diseases accounting for a large portion of the mortality. The underlying aging process has not changed, but the improved public health and medical measures of modern times have completely altered the life expectancy. Nutritional factors alone, for example, seriously complicate the investigation of inherent changes in blood pressure levels, not only in different centuries but in different countries in the same year.

The two curves shown in figure 6 have three characteristics in common. They show a decreasing mortality rate during the first decade of life; they show a minimum mortality rate during the second decade; and they show a common maximum life span of approximately 100 years. Whether the first two characteristics have anything to do with aging is a controversial issue depending on definitions. They seem to be inherent since they have not been altered by extreme changes in environmental factors. The concept of a maximum life span has been accepted because for practical purposes the longest human life spans over a period of recorded history have not varied significantly from 100 years. This would not be true if the biologic process were not limited by inherent factors. If death were due solely to the "wear and tear" of environment, the maximum as well as the mean duration of life would vary over the centuries and in different surroundings. While the mean life span has shown such dependence on environment, the maximum life span has not. To date improved environment has not altered the life expectancy of persons over 70 or 80 years. This fact is evidence that the life span in the older ages is dependent more on inherent or metabolic factors than on extrinsic or environmental con-

ditions. The opposite might be expected for the following reason. Inherent factors are fixed at conception, at which time they are for all practical purposes the only factors concerned in the organism. Throughout uterine and extrauterine life the environment continually acts on the individual so that any cumulative effects of environment should be greatest at the end of the life span. In spite of the great variety of environmental stresses centenarians have experienced, the length of their life span is quite fixed. This fixed maximum life span is a strong argument that death at these ages is due primarily to inherent factors and secondarily to the effect of extrinsic forces.

It is clear, then, that environmental conditions alone do not account for mortality. Each species seems to have a fixed maximum life span independent of wide ranges in environmental conditions. However, the variations in the life span of the members of the group are due to the interactions of extrinsic forces and inherent susceptibilities.

Partial Solutions

Four pitfalls need to be avoided. First, it should not be assumed that the number of people dying at any age is related to the degree of health of those who are alive at that age. Second, it should not be assumed that the curve formed by joining levels of physiologic measurements of different individuals at different ages (cross-sectional data) is necessarily a curve typical of the aging process of any one individual or group of individuals. Third, it should not be assumed that a characteristic common to all members of the species is being measured when only the survivors who are not lost from the sample by death are considered. Fourth, it should not be assumed that any statistic measures the inherent rate of aging until there is sufficient evidence that it is not in part, at least, the effect of special environmental conditions.

These obstacles in uncovering the nature of the aging process are in varying degrees self-evident. The difficulties arise from three sources: the assumption of a simple relationship between mortality rate and physiologic age, the assumption of inherent homogeneity, and the failure to allow for the complicating factor of environmental forces superimposed on inherent characteristics. These obstacles may be partially avoided but never completely eliminated. Use of mortality statistics in studying the aging process has least to offer; it is based on premises from all three sources.

The elimination of the assumption of the relationship of physiologic age and mortality, the partial elimination of the effect of environmental influences, and the partial elimination of the influence of changes in the nature of the group sampled (degree of heterogeneity) can be accomplished by selecting for examination parameters of structure or function which are independent of the cause of death and which are not apparently influenced by or causally related to death. Since no single function is generally accepted as being a measure of physiologic age, those which are both independent of and incidental to causes of death can be considered together. If several such parameters were measured or counted, the influence environment or death might have on any single parameter would tend to be cancelled out. When carried out by a cross-sectional approach, the results define the upper and lower limits of the parameter compatible with life at each age. The range will define the maximum variability which might occur in the shape of the curve in individuals. A study of this sort has been carried out on incidence of lesions observed at postmortem examination (5) and will be included in another paper of this series.

The aging curve of subtypes or of individuals can be studied most practically by a combination of cross-sectional and longitudinal data. Figure 7 is a hypothetical diagram combining the two types of approach. It shows how the trend of a function may be downward over the life span while death is associated with a high function. If such a function is not associated with clinical signs or symptoms, it may not be obvious which direction indicates a poor prognosis. If aging in man fol-

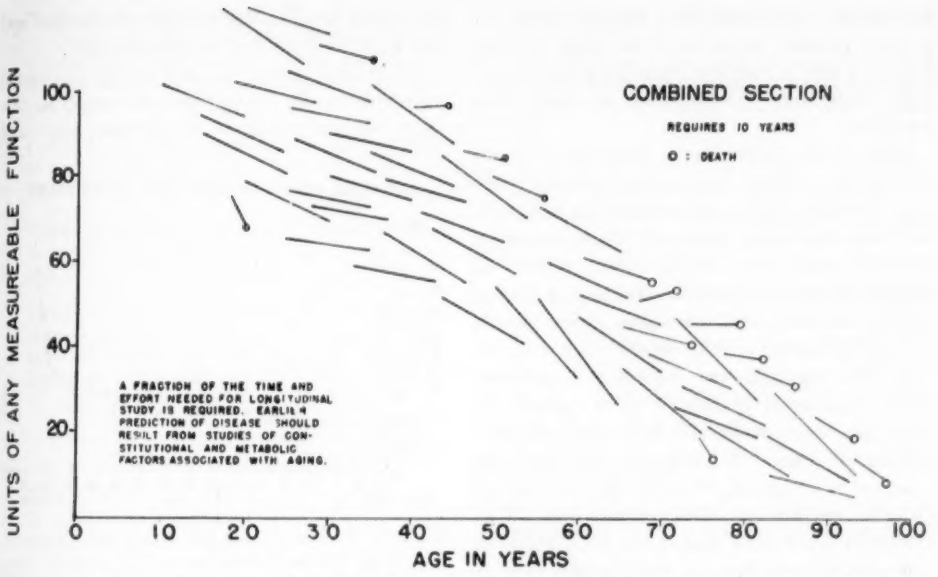

FIG. 7. Combined cross- and longitudinal-section. Hypothetic analysis of the aging process. The situation represented is that in which a rising function is associated with mortality while the function has a tendency to diminish with increasing age.

lows varied pathways, this approach will identify the subtypes provided the sampling is sufficiently large.

A third partial solution may be had by studying identical twins to discover the extent of the influence of different environments on physiologic age under conditions of constant hereditary background. Few studies of this sort have been made (8, 9). Once the contribution of environment to disease and mortality is known, the inherent characteristics of the aging process can be studied.

DISCUSSION

It is safe to say that the average rate of inherent aging of man throughout the life span of the species will never be known. Such knowledge depends on a means of separating extrinsic from inherent factors predisposing to death. If such a means became available, it would then be necessary to extrapolate the rate of aging of those whose death was brought on in part by environmental circumstances. A set of ideal environmental conditions which would be optimal for all and would not tend to shorten life does not exist. While most of the extension of life span over the centuries has resulted from improvement of environmental conditions, the inherent limit of life of some individuals is now being passed. For example, the otherwise inherent limit of life of diabetics, whose disease shows a hereditary weakness, has now become meaningless because of insulin. The use of data from such individuals may complicate a study of the inherent factors involved in aging. Exclusion of these from the measurements of the rate of aging, however, on the grounds that they are not representative means that the population being sampled does not remain constant. Since some relationship between life span and physiologic age probably exists, distortion of the true curve of physiologic aging could be expected. Similarly, there is no known or theoretic way of extrapolating a function beyond death to discover what course the aging process would

have taken if the individual had not died. If it were possible to do so, it is obvious from figures 5 and 7 that the resulting curve might differ significantly from that obtained from survivors.

Still another difficulty in measuring the inherent rate of aging involves the practical question of what single measurement can be identified with the aging process. The assumption that one exists may not be valid. Health of the individual and therefore life itself is limited by the resistance of the weakest organ system. It may be assumed that organs vary in their rates of aging from one individual to another. If environmental conditions were optimal in all people there would still be a wide distribution of life spans. Nevertheless, changes seem to occur in all members of the species—and of all other species—which limit life span. The few who reach that limit have been atypical. The typical members of the human race in the United States at present are those who died in their eighth decade, more people dying in this period than at any other time. The perspective of the next century may reveal how much of this group has reached its inherent life span and how much of its mortality is a result of environment. If the gradual shift of the mean and mode of mortality from younger to higher ages since ancient Roman times (fig. 6) continues, soon man will either break through his "maximum life span" or it will be exceptional not to live into the 90's where the mode will eventually reach 100. This is shown graphically in figure 8, where the great acceleration upward of the mean life span in recent years makes the future unpredictable.

Whether the so-called degenerative diseases which constitute most of the causes of death among the typical members of our own population are primarily of extrinsic or intrinsic origin is an academic question. It has already been demonstrated that diseases which are primarily of intrinsic origin are susceptible to treatment. Diabetes, rheumatoid arthritis, and hypertension are recognized as having hereditary backgrounds, but they can be controlled. Whether the aging process itself can be controlled will not be known until it is demonstrated.

In future papers of this series the partial solutions to the limitations discussed in this paper will be considered in greater detail and approaches to morbidity and mortality statistics will be offered.

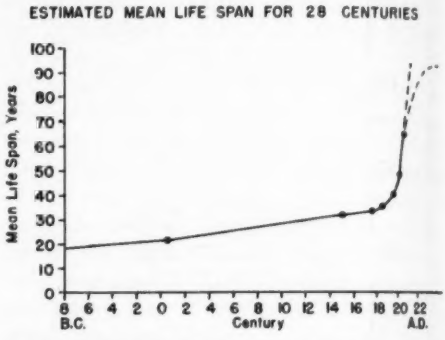

FIG. 8. Estimated mean life span over 28 centuries. The mean is rapidly approaching the accepted maximum life span. Two alternatives are possible. The mean will break through the "maximum" or will level off near 100 years.

SUMMARY

1. Certain fallacies and limitations in the interpretation of data on the nature of the aging process have been discussed. Mortality statistics and both cross-sectional and longitudinal data are limited in the information they can give about the inherent rates of aging of man.

2. Partial solutions to the problem are offered.

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600 South Kingshighway, St. Louis 10, Missouri.

FINANCIAL SIGNIFICANCE OF LONGEVITY IN PUBLIC ASSISTANCE

A Brief Study of an Old Age Assistance Mortality Caseload

JOHN J. GRIFFIN

(From the Bureau of Old Age Assistance, Board of Public Welfare, Somerville, Massachusetts)

FINANCING the final years of our aged citizens constitutes one of the paramount problems confronting the nation. Since the physical and mental well-being of these elderly adults is intimately related to their socio-economic security this matter is of great interest to geriatricians as well as to political scientists, economists, and sociologists.

Numerous attempts have been made during recent years to correlate the data available from diverse sources on the economic status of our senior population. These efforts, which have met with various degrees of success, have been aimed mostly at en masse evaluations. While a skeletal supply of important information has been collocated from census analyses, labor force studies, Social Security statistics, pension tabulations, and similar sources, notable gaps remain, particularly in respect to specific detailed findings of an illustrative character. We are repeatedly assured, for example, that there are approximately 13,500,000 persons 65 years of age or over in the country, that some 4,000,000 of these derive income from their own or their spouses' earnings, that more than another 3,000,000 are beneficiaries of a governmental retirement program, that nearly 3,000,000 more are recipients of Old Age Assistance, and that the rest have independent reserves or depend upon relatives, charitable agencies, or church charities.

These figures leave many questions unanswered. Lacking, for example, is accurate evidence as to the extent to which the different kinds of income overlap. Nor does the literature indicate the experience from the viewpoint of adequacy of public or private pension systems. Nor do we have any appreciable fund of knowledge as to the actual tenure of annuities, although actuaries apparently have sufficient guidance for their purposes. Access to data demonstrating the average aggregate cost of maintaining pensioners is not generally obtainable. A host of kindred questions continue to pique the curiosity of students desirous of making a multi-disciplined approach to the problems of the aged.

The inquiries indicated, it should be stressed, have very practical bearings on the soundness of long-range planning in several spheres of action. The answers, for instance, are matters of critical moment to institutional administrators in the process of establishing eligibility requirements and in assessing the risks involved in undertaking contractual obligations. They are likewise of real consequence to private corporations in projecting investments and to public agencies in calculating the adequacy of appropriations over the course of time. Indeed, in the ultimate analysis, the answers are fundamental for proper formulation of retirement policies and especially for estimating the concomitant costs of medical care. Appraisal of the latter factor as a basis for inclusion in future retirement planning will loom increasingly important in the next few decades, if the predictions of the population experts are to be trusted.

It is in the light of these and relevant postulates that this short study of an Old Age Assistance mortality caseload in Somerville, Massachusetts, was undertaken. The main objectives were to determine the longevity of Old Age Assistance recipients and to compute the related costs on a factual basis, keeping in mind the principal characteristics of the human congeries.

Somerville is a highly congested autonomous municipality 4.22 square miles in area, with a

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population of 103,500. As in all other Massachusetts communities, its Old Age Assistance program is locally administered but state supervised in conformity with a statutory legislation (2). Massachusetts was one of the first states in the nation to provide public assistance to the aged, its plan antedating the Federal Social Security Act by some five years, having become effective on July 1, 1931. The original law made eligibility contingent upon reaching the age of 70 and documented proof of 20 years' residence. Acceptance of the provisions of the congressional enactment liberalized these qualifications to 65 years of age and to 5 years' and later to 3 years' residence out of the preceeding 9 years. Citizenship, not demanded by the Federal requisites, continues to be a legal necessity in Massachusetts. Financially, the program is a three-tiered affair with the federal, state, and local entities sharing responsibility for costs. The federal government pays four-fifths of the first $25.00 monthly and one-half the remainder up to $55.00, or as is often said more conveniently, "one half up to $55.00 plus $7.50," which equals $35.00 of the first $55.00. The State pays two-thirds of the remaining grant and the community of legal residence the final fraction, which ranges from about one-sixth to one-eighth of the total outlay. Since the average grant is approximately $73.00 monthly and since the U. S. Government does not participate in the expenses above $55.00, it is clear that virtually the entire cost of medical and hospital care is borne by the state and local taxpayers (3). Indeed it may be simply concluded that it is the expenses for medical care (including hospitalization) which comprise the preponderant portion of the sum subsidized by the locality of residence or the place of settlement (4). The gross expenditures and net cost to the city, over the course of years, may be seen at a glance in table 1, which also illustrates the steady expansion of the caseload and related percentage-wise rise in disbursements.

Caseload

During the federal census of 1950 some 9,492 residents of Somerville, or roughly 9 per cent, admitted to being 65 years of age or over. The annual Old Age Assistance caseload indicates that somewhat more than a quarter of the total aged population receives public relief. During the fiscal year July 1, 1951, to June 30, 1952, the period under study, 2553 individuals received Old Age Assistance. Of this number, 1671, or 65.5 per cent, were women, and 882, or 34.5 per cent, were men.

Of the 1671 women, 123, or 7.4 per cent, died, while deaths among the 882 men equalled 93, or 10.5 per cent. Of the aggregate toll of 216 deaths, therefore, the 123 women represented 57 per cent, and the 93 men, 43 per cent. It is the mortality caseload of 216 with which this investigation is concerned.

Age

The cumulative living spans of the 93 men who died totalled 7199 years, or an average of 77.4 years. The total for the 123 women who died amounted to 9777 years, or an average of 79.5 years. Taken together the amassed time equalled 16,976 years, or an average of 78.5 years.

Duration of Assistance

An analysis of the official records shows that the 93 men received assistance to a total of 6965 months, or an average of 6 years and 3 months. Oddly enough the comparable result for the women is identical, since the 123 women were aid clients for a total of 9211 months, or an average of 6¼ years. Coincidentally, the figures indicate that the over-all average age at the time of application for public assistance was more than 72 years. This fact, which is contrary to popular opinion, journalistically cultivated, serves to demonstrate once again that governmental help is a last desperate resort for a residual group of our elderly citizens. Relevantly, we may append the observation that the total number of *months* of assistance, namely 16,176, may well be contrasted with the total number of *years* lived, namely 16,976 years. Indeed, since the average age at time

TABLE I. ANNALED CHART OF AGGREGATE EXPENDITURES SINCE DATE OF ORIGIN

Year	No. of Cases on Jan. 1	No. of Cases on Dec. 31	Cost for the Year		Refunds, Recoveries, and Reimbursements	Net Cost for the Year	Percentages of Gross Costs Represented by Net Costs
			Gross	%			
1931–(8/17)	14	161	$ 13,710.92	0.10	.....	$ 13,710.92	100.0
1932	161	308	86,803.88	0.50	$ 37,528.08	49,275.80	56.8
1933	321	355	108,297.78	0.66	39,897.84	68,399.94	63.3
1934	355	434	128,777.64	0.78	44,255.41	84,522.23	65.6
1935	434	567	157,985.74	1.00	60,633.52	97,352.22	61.6
1936	567	1009	234,129.58	1.43	144,949.77	89,179.81	38.1
1937	1025	1220	397,203.74	2.40	265,337.37	131,866.37	33.2
1938	1241	1363	464,592.63	2.80	368,441.05	96,151.58	20.7
1939	1363	1527	524,758.50	3.20	415,668.01	109,090.49	20.8
1940	1527	1569	534,405.27	3.30	444,487.63	89,917.64	16.8
1941	1569	1606	541,864.00	3.40	459,764.27	82,099.73	15.2
1942	1574	1492	578,141.50	3.53	496,734.68	81,406.82	14.0
1943	1470	1396	615,477.63	3.71	516,158.32	99,319.31	16.0
1944	1393	1314	658,940.37	4.02	551,228.53	107,711.84	16.3
1945	1314	1357	719,709.88	4.31	627,735.49	91,974.39	12.8
1946	1357	1616	914,699.75	5.60	724,080.91	190,618.84	20.8
1947	1616	1796	1,128,792.45	7.00	889,141.71	239,650.74	21.2
1948	1796	1914	1,341,752.67	8.11	1,088,921.14	252,831.53	18.1
1949	1918	2170	1,567,412.50	9.62	1,304,093.15	263,319.35	16.8
1950	2170	2256	1,852,724.61	11.31	1,612,192.84	240,531.77	12.9
1951	2240	2232	1,831,562.43	11.17	1,710,686.34	120,876.09	7.0
1952	2224	2124	1,974,867.49	12.05	1,721,304.21	253,563.28	12.9
Totals	27,649	29,786	$16,376,610.96	.....	$13,523,240.27	$2,853,370.69	17.4
Percentage	.....	.....	100.0	100.00	82.6	17.4	.....

of application was beyond 72 years, and since the average length of stay on assistance rolls was but 6¼ years, it is clear that this clientele, on the average, lived for a longer period beyond age 65 without public assistance than the period during which they received it.

Marital Status

In view of the fact that the term of receiving assistance (6¼ years) was the same for both sexes, the matter of marital status assumes particular interest. Analysis reveals that of the total mortality caseload of 216, all but 22 or 10.2 per cent, were married at some time. Of the 194, or 89.8 per cent, who were or had been married, 56, or 25.9 per cent, had living spouses at the time of their death, 130, or 60.2 per cent, were bereft of their partners, 5 or 2.3 per cent, were estranged, and only 3, or 1.4 per cent, were divorced. The detailed breakdown of the marital status of the caseload may be seen in table 2.

The fact that most of the persons in this long-lived group were married at some time accords with statistical anticipations. Not only do most adults in the United States marry but standardized death rates make manifest that the married outlive the single (6). The fact that 74.8 per cent of the women were widows while but 40.9 of the men were widowers also conforms to expectations. Available studies demonstrate that where wife and husband are the same age at the time of marriage, her chances to survive him are 3 in 5, while her chances are 2 in 3 if he is 5 years older (1). The economic consequences of such a fact are reflected in our Old Age Assistance experience. It is interesting to note, however, that in the present instance the average age of application for all the women was more than 73 years. This would seem to suggest that the women who were widowed comparatively early in life had struggled successfully to maintain themselves (and their families) almost to the end.

Children and Their Contribution

Children have long been considered a source of economic assistance to their aged parents. Projections in this field are often based on vulnerable hypotheses. Given the new longevity of parents, the marital and parental obligations of most children, our luxury-centered economy and present rate of taxation, the potentialities of children to support needy elders diminish almost to the vanishing point. The assistance caseload under study offers particularly valuable evidence because of the low incidence of sundered marriages.

Of the 85 men who were married, only 55, or 64.7 per cent, were fathers of record, while only 77, or 70.7 per cent, of the 109 married women were mothers. In other words, only 132 of the 194 potential parents, or 68 per cent, had progeny. The high incidence of childlessness is of importance in gauging the significance of marital status in relation to eventual need.

The reproductive rate of those who were parents was low. The 55 men had 185 sons and daughters, or 3.3 children per father. The experience of the women was similar; the 77 mothers bore 253 offspring, or 3.3 per marriage.

Of the total of 438 sons and daughters, 336,

Table 2. Marital Status of Clients in Mortality Caseload

Marital Status	Men	Percentage	Women	Percentage	Combined	Percentage
Married	41	44.0	15	12.2	56	25.9
Widowed	38	40.9	92	74.8	130	60.2
Separated	5	5.4	0	00.0	5	2.3
Divorced	1	1.1	2	1.6	3	1.4
Single	8	8.6	14	11.4	23	10.2
Total	93	100.0	123	100.0	217	100.0

or 76.7 per cent, were themselves married, while 77, or 17.5 per cent, remained single. Of the remaining 5.8 per cent, or 25 persons, 13 were widowed, 7 were separated, and 5 divorced. The pattern of marital stability characterizing the older generation seems to be reflected in the younger group.

In measuring the economic meaning of the adult children to their elderly parents, it is necessary to distinguish between voluntary support and mandatory contributions. Under Massachusetts law children of assistance recipients are liable, according to certain norms, to contribute to the maintenance of their needy parents. Single children at home are allowed a basic exemption of $2000.00 plus federal and state taxes, with one-third of any excess income going to the aged recipient. Single children away from home have a $2250.00 basic exemption. Married children have an exemption of $3250.00, irrespective of their spouse's employment status, and there is a $500.00 additional exemption for each child of a married person. Any extenuating circumstance is considered in weighing ability to contribute, and there are special exemptions for extraordinary medical needs, educational costs, and like expenditures.

It is not surprising therefore, to discover that very few sons and daughters contributed to the financial support of their aged fathers and mothers. In fact just 36, or 8.2 per cent, of the 438 children, contributed either voluntarily or because of legal compulsion. These 36 made payments totalling $710.42 monthly, an average of $19.73 monthly, to a total annual sum of $8,773.04. Of 12 men who thus benefited, 5 obtained mandatory sums averaging $20.47 monthly, or $1,228.56 yearly, and 7 were given voluntary offerings averaging $29.18 monthly, or $2,651.60 annually. The dozen men recipients therefore, had an annual income from this source of $3,880.16. Some 24 mothers were in a similar position. Of these, 21 were granted an average of $18.83 per month because of the legal mandate and only 3 received voluntary donations averaging $4.08 monthly. The total income thus procured by these women was $4,892.88 yearly. These amounts of course, were deducted from the budgeted assistance grants which the recipients would otherwise get. In addition, 5 men confined to commercial nursing homes received earmarked gifts from their children, averaging $38.00 monthly, or some $2,280.00 yearly. These latter were not deductable from standard assistance grants because they were specifically given by children to enable their institutionalized parents to pay weekly care rates in excess of those allowed by state authority.

Other Income: Social Security, Private Pensions

Under the Social Security Act two separate and distinct programs for the aged were established. One was the *assistance* program which has been discussed. The other was a nationwide *insurance* program entirely federally controlled and deriving its funds from compulsory tax-premiums levied on employers and employees. The latter, being an insurance program, requires no means test for eligibility and those covered by its provisions are entitled to its benefits by legal right, irrespective of their resources, upon reaching the age of 65. The insurance program was originally intended to supplant almost entirely the assistance plan, but because of inadequate benefits it remains far from accomplishing its objective and hundreds of thousands of insurance beneficiaries require supplementary assistance to subsist.

Since our recipients on the average were more than 72 years old at the time of application for assistance, it is clear that they were well advanced in occupational age at the height of the economic depression in 1936 when the Social Security Act became operative. Accordingly less than half of the men and but slightly more than a tenth of the women were insurance beneficiaries, and the insurance income of these was low.

Of the 93 men only 42, or 45.1 per cent, received Old Age and Survivors Insurance Benefits. The average benefit was $45.14 monthly and the aggregate amounted to $1,895.90 monthly, or $22,750.80 yearly. Just 13, or

10.6 per cent, of the 123 women qualified for O.A.S.I. and their average benefit was a paltry $26.61, which amounted to a total of $345.92 monthly, or $4,151.04 yearly. In combination therefore 55, or 25.5 per cent, of the 216 cases, received $26,901.04 yearly, or an average of $40.75 monthly.

The phenomenal growth in private industrial pensions which has taken place within the past decade is, of course, not reflected in this experience. In fact, only 7 individuals had income from this source. Three retired men, representing 3.2 per cent of the men, had pensions totalling $1,830.48 yearly, or an average of $50.85 per month. Four women pensioners, or 3.2 per cent, received $1,433.64 yearly, or an average of $29.87 monthly. Hence the economic significance of this source of income was negligible as far as our assistance caseload was concerned.

Resources: Realty and Liquid Assets

Our experience attests that Old Age Assistance recipients as a class fall into the category of propertyless wage earners. But 22, or 10.2 per cent, of the 216 grantees owned residential property. Eleven men and the same number of women owned their own homes. The 11 men, representing 11.8 per cent, owned homes valued in toto, for assessment purposes, at $68,600.00, or an average of $6,255.00. The residences of the 11 women (9 per cent) were appraised at $51,600.00, or an average of $4,690.91. The actual market value of the property may be assumed to be at least one-third higher than the assessed valuation. Under the terms of a new statute which became effective January 1, 1952, the city placed liens on all real property of Old Age Assistance recipients with a view to obtaining reimbursement for aid granted at the time of the recipient's death, or, previously, if the property were sold or transferred. Since most property is mortgaged, such liens are generally equivalent to second encumbrances. An exemption of $1500.00 to a certain extent in both cross-sectional and based on current market values and including life insurance is allowed to the estates of the deceased.

As far as readily liquidatable assets are concerned, some 38 individuals, or 13 per cent, had savings bank accounts totalling $12,411.54, or an average of $326.62. A larger percentage of women showed this type of thrift than men and 27 women, or 22 per cent, had savings of $9,610.86, an average of $355.96, while only 11 men, or 11.8 per cent, saved $2,800.68, or $254.61 each.

Those who are familiar with the almost universal anxiety of the aged to guarantee themselves a "decent burial" can best evaluate the significance in terms of emotional security of these small savings. Remembering the fact that the 1952 dollar had a purchasing power of $0.53 in terms of the 1939 dollar, we can realistically estimate the buying value of these inflation-hollowed bank accounts.

A sparse few had other assets. Thirteen persons, or 6 per cent of the whole, were proprietors of stocks or bonds worth in all $986.29, or just $75.87 per owner. Four men had negotiable assets with a market value of $597.00, or $149.22 each, and 9 women had securities worth $389.29, or an average resource of $43.25.

Life Insurance

In this insurance-conscious nation it is not surprising to find that life insurance was by far the most prevalent type of thrift investment used by the persons under study. It should be recalled that these people were practically beyond the insurable age before the remarkable expansion of life insurance coverage which has developed since 1940. A few facts should suffice to illustrate this point. Latest reports for example, demonstrate that in 1952 the number of policyholders was 21,000,000 greater than ten years before, 45 million more than in 1922, 76 million more than in 1902 (5). Indeed, at the end of 1952 some 88,000,000 American policyholders with 219 million policies had insurance coverage exceeding the U. S. national debt limit, that is, $276.6 *billion* dollars worth.

Of the 216 persons in our mortality caseload 148, or 68.5 per cent, had insurance grossing $72,426.14, or an average of $489.36 per insured. Of the 93 men, 60 were insured to a total of $31,060.00, or to an average of $517.67. These 60 insured represented 64.5 per cent of the group of men. Of the 123 women, 88, or 71.5 per cent, carried $41,366.14 insurance, or an average of $470.07. These figures further indicate the comparatively low economic status of the members of the group since even in 1902 the average policyholder held insurance of $780.00 whereas today he has a coverage of $3,100. Nevertheless, considering the likelihood that many of the insured cash-surrendered policies during the economic debacle of the thirties and the probability that not all insurance, especially in cases where children paid premiums, was revealed, the incidence of insurance possession is notably high.

Cemetery Plots

The availability of convenient burial lots is of great moment in providing for proper final disposition of the aged. In this experience more than half—117, or 54.2 per cent—had such placements reserved. Of the 93 men, 49, or 52.7 per cent, were so provisioned, and of the 123 women 68, or 55.3 per cent. All, however, were given suitable interment and their funerals were conducted under the auspices of competent morticians. In fact only 12, or 5.5 per cent, called for the restricted participation in funeral expenses allowable to the Bureau. The availability of an amount equal to 3 times the primary benefit to retired workers who are O.A.S.I. beneficiaries helps to diminish appeals to assistance authorities. In the present experience, the Bureau contributed $1,140.00 toward the funeral costs of 9 men, or an average grant of $126.66, and $350.00 for 3 women, averageing $116.67.

Gross Assistance Expenditures

With our background material in order, the picture of financial costs involved in maintaining the caseload of 216 persons during the period of assistance becomes more meaningful. Individual assistance grants, of course, are determined by budgeted needs in accordance with state standards.

During the entire span of time during which the 216 clients were aided they received a grand total of $825,812.41, or an average of $3,823.20. Only 6 persons, or 3 per cent, received more than $10,000. However, more than a third—74, or 34.4 per cent—received over $5,000.00. On the other hand, 76, or 35.2 per cent, received less than $2,000.00. A detailed breakdown may be seen in table 3.

Differentiation by sex shows that the average woman received more than the average man. The 93 men obtained a total of $314,194.27, or an average of $3,378.43. The 123 women were assisted to a total of $511,618.14, or an average of $4,159.49.

Medical Assistance

Under the Massachusetts law, Old Age Assistance recipients are allowed to engage physicians of choice and all their prescribed medical needs including hospitalization, medicines, prosthetic devices, dental, orthopedic, ophthamologic, visiting nursing, housekeeping, convalescent, and domiciliary care, and related services, are provided. A glance at the ledger entries suffices to show the significance of the medical care program.

Of the complete outlay of $825,812.41, some $64,914.06, or 7.8 per cent of all assistance, was spent for medical care. Of the $511,618.14 total granted the women, $32,308.00, or 6.3 per cent, was for medical needs. The proportion in the case of the men was notably higher. Of their total $314,194.27 some $32,606.06, or 10.4 per cent, was used for medical care.

Of the whole contingent of 123 women, all but 10 required some expenditures for medical care. If we divide the sum expended for their care by 113 (those requiring medical care) we find that the average cost actually was $285.82. If we use the total of 123 the cost equals but $254.53 for an over-all average. In the case of the men, 90 of the 93 obtained medical aid.

TABLE 3. AGGREGATE ASSISTANCE PAYMENTS RECEIVED BY 216 CLIENTS

Gross Payments	Men		Women		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Less than $1,000	19	20.3	20	16.3	39	18.0
$1,000 to $2,000	23	24.7	14	11.4	37	17.2
$2,000 to $3,000	10	10.7	15	12.2	25	11.5
$3,000 to $4,000	8	8.6	11	9.0	19	8.8
$4,000 to $5,000	8	8.6	14	11.4	22	10.1
$5,000 to $6,000	6	6.5	21	17.1	27	12.5
$6,000 to $7,000	7	7.6	12	9.8	19	8.8
$7,000 to $8,000	6	6.5	5	4.0	11	5.1
$8,000 to $9,000	2	2.2	2	1.6	4	1.8
$9,000 to $10,000	3	3.2	4	3.2	7	3.2
$10,000 to $15,000	1	1.1	5	4.0	6	3.0
Total	93	100.0	123	100.0	216	100.0

the average for the 90 being $362.29 and for the whole group of 93, $350.60. Remembering the average age of over 72 years at the time of application and recalling that these expenses were distributed over an average period of 6¼ years, the findings are astonishingly low. The figures also tend to indicate that a larger proportion of men than of women are moved to ask for assistance chiefly because of medical indigence. The social case records buttress this conclusion. It is only the exhaustive costs of medical care which drive a high percentage of men to apply in their economic extremity for public relief. The aged in question it should be observed, were "too old too soon" to enjoy the benefits of prepaid medical insurance.

Incidentally, if we deduct the medical costs from the gross expenditures, we find that for regular subsistence the women received $479,310.14, or an average of $3815.53, and the men were granted $281,588.21, or an average of $3027.83.

NURSING HOME COSTS

Further illumination is thrown on the character of the component elements in public assistance when we study the expense for commercial nursing home care. Thus, of the grand total of $825,812.41 spent in assistance, $105,661.86, or 12.8 per cent, was consumed in subsidizing these quasi-institutional arrangements. Of the $511,618.14 given to the group of women, $76,270.95, or 14.9 per cent, went for this purpose. So also of the total $314,194.27 in disbursements to the men, $29,390.91, or 9.3 per cent, was for maintenance in nursing homes. These expenditures were incurred for 65 persons, or 30 per cent of the caseload of 216 individuals.

Of the total $64,914.06 expended for medical care, $8,574.80, or 13.2 per cent, was for residents of domiciliary facilities. This $8,574.80 represented about 8 per cent of the total $105,661.86 spent for nursing home services. Of the $29,390.91 nursing home expenses for men, $4,403.84, or 15 per cent, was for medical requirements, while of the $76,270.95 expended for the women, $4,170.96, or 5.4 per cent, was for medical care. Some 13.5 per cent of all medical care for men was during their stay in nursing homes. The comparable figure for the women was 12.7 per cent. Of the total 123 women, 40, or 32.5 per cent, received nursing home care at some time, while of the 93 men 25 or 26.1 per cent received such care.

Summary

Analysis of the mortality caseload of the Old Age Assistance Bureau of Somerville, Massachusetts, for the fiscal year terminating June 30, 1952, consisting of 216 persons, shows that the average client's "assistance longevity" was 6¼ years and the average total of public monies received was $3,823.20, or approximately $600.00 yearly. In fact a division of the total number of months of assistance, namely 16,176, into the gross aggregate of expenditures of $825,812.41 indicates an average monthly grant over the entire period of assistance of $51.05. A more detailed computation shows an average of $45.25 for the men and $55.54 monthly average for the women. The lower figure for the men is apparently due to a greater availability of income from other sources.

While the averages may not seem very impressive in a nation accustomed to fiscal figures of many billions, reference to table 1 demonstrates the appreciable cost to a community of assistance to the aged over a period of time. Moreover, it is well to bear in mind that averages can be deceptive. In the present experience, for instance, while one individual received assistance for only 10 days, another was a public charge for 19 years and 7 months. So too while one person received a total of only $23.73, another benefited by a total of $14,687.00.

A study of the financial facts shows that while only 7.8 per cent was spent for medical care, including hospitalization, 12.8 per cent of the total was expended for nursing home care. These figures are of particular interest because Massachusetts has one of the most generous Old Age Assistance programs in the country and it provides adequate medical care centering in the privilege of physician of choice.

A review of the other sources of income and the various types of assets available to the clientele demonstrates that we are dealing with a residual group of wage earners and their dependents whose marginal mode of existence placed them on the economic periphery.

While far-reaching conclusions could scarcely be justified on the basis of such restricted local data, this brief study does provide insight into the intimate workings of our national Old Age Assistance system. Its ultimate validity must remain to be evaluated in the light of comparative analyses made in other representative sections of the nation.

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AGING: A CROSS-SECTIONAL SURVEY AND ACTION PROGRAM

DAVID FANSHEL, BERNARD KUTNER, PH.D., AND THOMAS LANGNER

(From Cornell University Medical College, Studies in Gerontology, New York, New York)

THROUGHOUT the country there has been a growing demand for new programs to meet the needs presented by the aged segment of the population. Social planners have been asked to spell out new ways in which health and welfare organizations might assist the older person in sustaining his physical and mental well-being during the later period of his life. Numerous gubernatorial conferences in many states have been called to map out over-all plans for governmental and voluntary agencies to attack the problem in its varied dimensions—housing, social security, health, and recreation. While some new programs have been implemented, there is general recognition that much more remains to be accomplished.

Prior to the development of new programs, there is need for research concerning the actual status of the aged person in terms of his basic needs and problem areas. Such research will enable those responsible for planning in this area to be able to develop services that are needed and will be used by the older person.

THE AGED IN AN URBAN AREA

This report will outline some preliminary results of an action research project on the problems of the aged which has been under way in the Kips Bay-Yorkville Health District in New York City since September, 1952. This health district (fig. 1) covers about 340 city blocks and houses 38,000 persons over the age of 60 out of a total population of 256,000, a concentration of older people greater than any other health district in New York City. A further reflection of the older composition of the area is the fact that it is the only health district in the City of New York in which the death rate has consistently exceeded the birth rate over the past two years. It is understandable, therefore, that great interest has been expressed on the part of health and welfare officials in formulating new programs to meet the needs of this group.

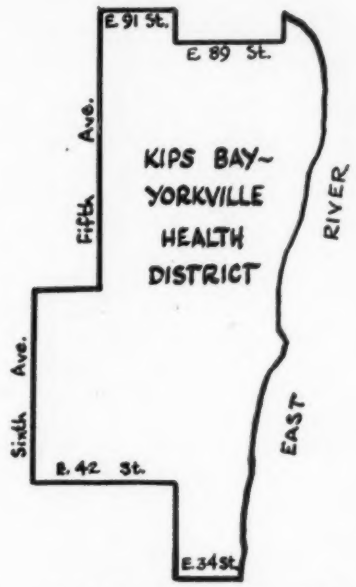

FIG. 1. Boundaries of the Kips Bay-Yorkville Health District.

Kips Bay-Yorkville has been aptly described by one sociologist (1): "Kips Bay-Yorkville is a congeries of urban contrasts. The world's most luxurious apartments—substandard tenement housing; expensive hotels—mean boarding houses; exclusive private schools—outdated, crowded public schools; cathedrals—humble chapels; ranking income tax payers—families on relief for years; 'the world's finest stores'—push carts; old American families—

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newly arrived refugees; all these and others go to make up . . . an urban area with a thousand problems generated by too many people trying to live in too little space."

For the sociologist interested in the problems of old age, these contrasts provide widely diverse variables by which aging can be studied. What problems do the aged share? What problems are related to their class position, their ethnic origins, marital status, and employment status? Are there unique programmatic problems posed by widowhood, retirement, illness, and so on?

The field survey research project undertaken in Kips Bay is somewhat unique in gerontologic studies since it involves the cooperative endeavors of social scientists and the medical profession through the Social Science Research Center of Cornell University, the Russell Sage Foundation, the Department of Public Health and Preventive Medicine of Cornell University Medical College, and the New York City Department of Health, as well as the active collaboration of many governmental and private agencies.

The purpose of the study was to provide a factual basis upon which to establish a program to serve the specialized needs of the aged. A field survey of aged persons residing in the area was designed to locate sources of problems and indications of unmet needs.

Nature of the Sample

Interviews were held in the homes of 500 aged residents, 312 women and 188 men, who were selected on the basis of a purposive stratified random sample—60 per cent were selected from the low, 30 per cent from the middle, and 10 per cent from the high income groups. These proportions were chosen on the strength of estimates of the segments of each group likely to utilize a service center for the aged. Interviews were carried on by a staff consisting mainly of trained social workers and covered many significant aspects of the lives of the respondents.

One hundred and seventy-four persons were currently married, 80 had never been married, 220—a very large number—were widowed, and 26 were either divorced or separated. Two hundred and one respondents were living alone, 172 with a spouse, 130 with a son or daughter, and the remainder lived with other relatives or were boarding out. Half of the sample had been living in their present domiciles for at least 10 years and nearly a fifth for 21 years or more. The various age categories (from 60 to 90) were adequately represented in the sample as were the various ethnic and religious groups. One hundred and twenty respondents were employed, 41 were self-employed, 38 were unemployed, and 164 were retired. There were 133 housewives, some of whom also were employed or retired from employment.

Health Status and Attitudes

An important interest for the medical profession in the investigation was the health status and health practices and attitudes of these 500 older people. For the sociologist there was an interest in the relation of health problems to class position, employment status, and living arrangements.

A total of 145 of the respondents reported themselves as having no diseases or illnesses that they were aware of, 224 reported 1 illness, and 83 reported 2 or more illnesses. (There will be an opportunity to confirm this information through interviews with the relatives and associates of the respondents and through contacting their personal physicians.) When asked to rate their health, 21 per cent reported their health as excellent and 34 as good; 26 reported their health as fair, 14 per cent as poor, and 5 per cent as very poor. Interestingly, 12 per cent reported their health as improved over the past five years and 60 per cent as the same. Half of the respondents thought their health was better than that of other people their age. The over-all good health of the group is attested to by the fact that two-thirds of the group spent no time in bed during the past year because of illness.

In the group studied, illness seemed to increase moderately as one goes down the economic ladder. Possibly a lifetime of heavy

physical activity for those in the low income group might later have resulted in a somewhat heavier incidence of illness.

Surprisingly no such difference was found in attitudes toward physicians and hospitals or in taking such preventive measures as going for a physical examination at least once a year. For example, our aged respondents were asked to agree or disagree with the following examples of stereotypes about physicians and hospitals: "Most doctors don't care how much they hurt you; Doctors tend to treat younger people better than older people; The trouble with hospitals is that once you get in you never know if you'll get out alive." More than 50 per cent refused to agree with any of the 6 negative stereotypes about physicians and hospitals and a little less than 10 per cent agreed with 3 or more.

It would seem that, regardless of station in life, most of our urban-living aged have a positive attitude toward good health practice. The major class difference is that almost all of the high income people were examined by private physicians whereas a third of the low income group went to clinics for this purpose. The public picture of the aged person as a frequent user of home remedies also seems to break down; only 8 per cent of the sample reported frequent use of home-made concoctions. Use of home remedies decreases with increased education of the aged.

Persons who live alone and were most socially isolated seemed to be less healthy than those who had a more active social life. It is possible that aged individuals starved for normal human affection and warmth will emphasize their illnesses in order to obtain some compensatory emotional reward. A number of hospitals in New York City report that many of their aged patients use their clinics mainly as a socializing experience; one such hospital was able to form a "cardiac" club for older patients to provide them with the social outlet they seemed to be seeking.

Public health officials are concerned with the question of the wisdom of setting up special facilities for older people to receive medical treatment. When interrogated about their preferences, twice as many respondents indicated that, if Kips Bay-Yorkville had a special medical center for older people, they would go there for treatment as indicated a preference for a center for all ages. This throws some doubt upon the assumption that older people resist the idea of special medical facilities for them.

Some measure of the emotional strains faced by the aged living in an urban area can be determined by the number of psychosomatic complaints they present. Almost 1 in 5 reported frequently being nervous and unable to sleep and 1 in 10 reported frequent headaches and constipation. A mental health index was developed by using 15 items from the interview schedule. About 7 out of 10 respondents seemed to maintain a sense of emotional well-being according to this index, whereas about 8 per cent displayed strong evidence of upset.

Those who were employed seemed to be under the least stress while the retired group had slightly more distress and the unemployed group even more so. One possible explanation of this would be that those for whom the question of employability seems resolved would be under less tension than those for whom there is yet uncertainty.

It was also noted that the women in the sample rated lower on mental health than the men. A large portion of these were widowed, and loss of the role of homemaker for a woman may have as distressful an effect as the loss of gainful employment for a man.

Physical health seems to be a very important factor affecting the mental health of the aged. Those who reported good physical health tended to show a good state of emotional well-being whereas the more illnesses reported the more psychosomatic and neurotic responses were shown. This tends to substantiate the observations of the Community Service Society in New York (2) that where physical health was a problem it loomed large in the adjustment pattern of the aged client.

Expressed Needs of the Aged

In order to ascertain what type of program could best meet the needs of old people, the older residents of Kips Bay were asked, "If there were a center which dealt only with the needs of older people, what do you think they should deal with?" Naming as many things as came to mind, the following expressed needs or problems in order of most frequent mention were: recreation, employment, health, finances, housing, help to meet new friends, education, legal, and family. Almost 2 out of every 5 aged persons mentioned recreation as an area with which a center should deal. About 1 in 4 were concerned with employment, health, and financial problems.

It is to be noted that the native-born Americans, English, and Irish-born tended to emphasize recreation and meeting friends nearly twice as much as the German, Czechoslovakian, and Hungarian-born respondents. Some explanation of this may lie in the fact that minority ethnic groups tend to be more highly organized and thus have more organizational or social groupings which can include their aged members. Minority groups also tend to build cohesive organizations that can later be adapted by the aged member to meet his situation as a retiree or widow. What may have been a social handicap throughout the individual's life span might become an asset in later life. At the same time, the foreign-born groups tended to emphasize financial problems more than did native-born, which is likely a reflection of different socio-economic status levels as well as cultural influences.

Individuals who tended to be isolated socially emphasized financial problems more than those who had families and friends around them. This may stem from the practical consideration that isolated aged people have fewer sources of financial support. One out of every 5 respondents had no friends at all in New York and more than half the respondents denied having close friends in New York—friends with whom they could occasionally talk over personal matters. This suggests that the concept of promoting old age clubs may serve a useful purpose for many aged isolates.

Other Features

Some other features of this group portrait of the aged in Kips Bay can be briefly outlined.

A little over 60 per cent of the sample voted in the last presidential election. This compares fairly well with the rest of the country. Twice as many respondents stated that they voted for Dwight Eisenhower as for Adlai Stevenson. Whether this is a function of class, ethnic membership, or is because of factors relating to old age remains for analysis. Sixty-six per cent believed older people should organize to obtain benefits for themselves.

In regard to sources of financial support, the following figures are of interest; 24 per cent were receiving Social Security, 12 per cent public assistance, 7 per cent pensions from private industry, 21 per cent support from children or other relatives, and 17 per cent from their spouses. Two out of 5 respondents believed that their standard of living was worse today; 1 out of 5 considered it to be better.

At least two-thirds of the sample spent more than one hour each day engaged in radio or television entertainment, 5 per cent more than six hours. Reading, walking, shopping, and visiting with friends were the major forms of recreation. Some of the reasons given for older people not joining nearby recreation centers included "the desire not to be a stranger," "not liking to go out much," and "too much trouble." However, almost 2 out of 5 respondents indicated a readiness to join a club of people their "own age only" in preference to a club containing younger people or for "people of all ages," if they were to choose between these alternatives.

Kips Bay-Yorkville Counselling Center

Based on these and other findings to be reported later, the Kips Bay-Yorkville Counselling Center was established on September 1, 1953, under a grant from the New York Foundation. The purpose of the Center is to

set up a pilot program for the aged, focusing on providing personal, family, and group counselling, information, medical appraisal of limitations, and referral to appropriate professional agencies. The staff is interdisciplinary, representing medicine, psychology, social work, and public health nursing. Concurrent with the operation of the program, an autonomous research staff will continuously evaluate the functioning and effectiveness of the program with the purpose of indicating the points at which the service is most effective and where it is in need of modification.

Summary

In a field survey of 500 aged people, 312 women and 188 men, residing in the Kips Bay-Yorkville Health District in New York City, a major observation was that a large majority of the respondents are in what they consider to be reasonably good health. They show few visible signs of emotional disturbance and do not regard themselves as a serious problem to anyone. Their needs are more related to practical circumstances than to factors stemming from personal disorganization. They seem quite responsive to socio-medical programs of a preventive nature and give promise of using such services if they were developed. The high income group would not respond to public programs but might to privately sponsored ones.

At the bottom of the scale is a group of people (somewhat less than 10 per cent) who seem extremely miserable. They have the characteristics of being in poor health, generally living alone and socially isolated, neurotic in their attitudes on a variety of questions, and very distrustful of the medical and other professions that might be mobilized to help them. They represent a basic challenge to social planning.

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1300 York Avenue, New York 21, New York.

THE RELATION OF HOME CARE TO LIVING ARRANGEMENTS

MARTA FRAENKEL, M. D.

(From the Department of Hospitals of the City of New York)

This paper is concerned with only one specific program of home care, the Home Care Service of the Department of Hospitals of New York City. The Department operates 34 hospitals, general and special, 16 of which render service in the patient's home in addition to service in the wards and clinics. By charter, these hospitals serve primarily the indigent and the medically indigent of the City of New York. People unable to pay for care receive free service, board, medical, nursing, and auxiliary care, drugs, laboratory tests, etc. Those who are able to pay, either in part or in full, are required to do so according to their means.

The Department's hospitals have slightly over 20,000 beds, about half in general, half in special hospitals. This includes approximately 3,400 beds in 2 hospitals for the chronically ill and 1,200 beds in a home for dependent aged. During the first six months of 1953 there was a daily average of 19,750 patients in the wards of the departmental hospitals. In addition, there was a daily average of approximately 2,000 patients on home care.

The home care program, which was started late in 1948 in a few selected hospitals as a pilot project, developed rapidly. In 1950, a total of 16 hospitals—13 general, 2 tuberculosis, and 1 chronic disease—operated home care services. The goal of a home care census of between 1,900 and 2,000 patients was reached early in 1952 and has been maintained since then.

Home care was conceived as a program for patients of all age groups who are in need of long-term care, the child with a cardiac condition, the arthritis, multiple sclerosis, or Hodgkin's disease patient, as well as the aged patient with the various chronic conditions occurring with increased frequency in that span of life. Our daily home care census usually includes 900 to 1,000 patients of 65 years and over. On May 31, 1953, 904, or nearly 45 per cent, of the patients were 65 years and over, including nearly 15 per cent of persons of 75 years and over (table 1). Disregarding the home care services of the two tuberculosis hospitals, the proportion of aged patients amounted to over 48 per cent.

TABLE 1. ALL PATIENTS ON HOME CARE SERVICE, BY AGE GROUP, MAY 31, 1953.

Age Group	*Number*	*Percentage*
Under 25 years	86	4.3
25-44 years	264	13.0
45-64 years	769	38.0
65-74 years	608	30.1
75 years and over	296	14.6
Total	2,023	100.0

Home care offered by the Department of Hospitals of New York City constitutes a continuation of the care in the wards for selected categories of patients. When on home care, patients have medical supervision and occasional service from visiting nurses. Social workers call on them at intervals and occupational and physical therapists come to the home when needed. Housekeepers are assigned on an hourly basis when required. Drugs are dispensed, specimens for laboratory tests are taken to the hospital, and items of equipment, such as hospital beds or wheelchairs, may be lent by the hospital.

The patients on home care retain their status as hospital patients; they are not discharged from the hospital but are transferred to "ward home." This policy guarantees continuity of the medical regime, so important in long-term illness; it furthermore secures full hospital care when the patient again requires it. He is then retransferred to the intramural ward of the hospital, a procedure which, arranged by the

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home care staff and performed by special ambulance, can be achieved smoothly. The concept of retransfer to a familiar hospital ward prevents the psychologic shock which so often hits patients and their families when a new hospital admission becomes necessary after discharge from the hospital had been interpreted as evidence of improvement.

Living arrangements at home, which may be adequate for the quiescent period of chronic illness, often are improper when the patient suffers from an acute exacerbation. A program which provides that, at times of medical contingency, a patient is retransferred from this home to the hospital ward has an extended scope. Often a patient becomes eligible for care in his own home who otherwise would have to remain in the ward or be accommodated in an institution of domiciliary type; patients for whom future ward care is anticipated do not have to be excluded from home care.

If a patient is considered a potential candidate for home care, a thorough medico-social study is conducted. In the recent past, an average of 700 to 800 hospital patients were evaluated each month. Usually approximately 550 to 600 were admitted to home care and 150 to 200 rejected. Between 40 to 50 of the rejections were because of inadequate housing or living conditions. The decision of whether or not to transfer a patient home is made on the combined consideration of physical, psychologic, and sociologic factors.

Eligibility for Home Care

Medical Characteristics.—The home care program was organized to take care of those patients who no longer require the services and facilities of a hospital but who, on the other hand, are not, or not yet, able to visit a clinic. The program is directed primarily toward patients in need of long-term care, mainly patients with chronic illness. However, it also accommodates patients with such so-called acute conditions as fracture of the femur. The most frequent diseases of the aged patients at present are listed in table 2.

In the census of May 31, 1953, only 48 of the 904 aged patients had cancer. When not in need of hospital or other institutional care, cancer patients are often able to visit a clinic. Occasionally a cancer patient is, upon his own or his family's request, transferred home for terminal care.

Table 2. Aged Patients on Home Care Service, by Diagnostic Category, May 31, 1953.

Diagnostic Category	*Number*	*Percentage*
Arteriosclerosis, hypertensive heart disease	354	39.2
Diabetes mellitus[1]	129	14.3
Fractures[2]	84	9.3
Other cardiovascular conditions	70	7.7
Neoplasms	53	5.9
Apoplectic stroke	50	5.5
Arthritic conditions	41	4.5
Respiratory conditions	28	3.1
Anemias, leukemias	20	2.2
Tuberculosis	17	1.9
All other	58	6.4
Total	904	100.0

[1] Includes amputations of the leg because of diabetic gangrene.
[2] In the majority of cases the fracture involved the neck of the femur.

The degree of disability of the aged patients on home care covers a wide range, reaching from those who are able to be up and about to those who are completely confined to bed. In the decision of whether the living arrangements permit a transfer to care at home, the degree of disability is often of more importance than the medical diagnosis.

Socio-Economic Characteristics.—There are a few tangible and many intangible elements which carry weight in the decision of whether or not the milieu of a patient is adequate and desirable for home care.

The patient has to be indigent or "medically indigent." Ward patients who, or whose families, have been assessed to be able to pay more than $2.00 toward the per diem hospital cost are not considered as medically indigent and hence not eligible for the Department's home care program. When they no longer need hospital care, they are discharged with the advice to secure care by a private physician.

Indigent patients on home care may be unable to cope with the living expenses, especially

when increased by the need for special diets, extra laundry, etc. Arrangements for financial support are then made with the municipal Welfare Department or with voluntary social agencies. The auxiliaries of the hospital's Social Service Department also often come to a patient's aid in financial difficulties.

The requirements for living and housing arrangements are that the patient have living quarters which are adequate, a bed of his own, and the amount of attendance that the person requires has to be either available or obtainable.

Categoric standards for an "adequate" home cannot be established. When one deals with aged, chronically disabled people in New York City the question as to adequacy of a home has to be decided upon an individual basis. Living arrangements and housing conditions differ greatly from one neighborhood to the next. In some sections of the city large families are crowded together in a minimum of space, some in old run-down tenement houses, others in new low-cost housing developments; in other neighborhoods many unattached aged people may be found living alone in furnished rooms; in still other sections, particularly toward the outskirts of the city, small one-family houses or bungalows are comparatively adequate for a two-generation family but inappropriate to accommodate three generations. Background, habits and tradition, cultural patterns, likes and dislikes, are so widely different among the various groups that any attempt at establishing standards would lead to failure.

Certain minimum standards of hygiene, sanitation, and cleanliness are, of course, indispensable. However, when the bed or bed linen is unsatisfactory, substitutes can be supplied. While a separate room may be a necessary requirement for some patients, it is not so for many others. When cherished food habits may seem contra-indicated for the patient, the social worker may arrange for dietary instructions. When the burden of housework, increased by a sick and aged family member, becomes too heavy, housekeeping help is supplied. Perhaps a neighbor or friend may be interested in accepting such a responsibility on an hourly basis and attend to cleaning, cooking, marketing, and other necessary functions.

The patient must be ready and willing to return home and the family has to be ready and willing to have him at home. To make home care successful, the patient has to be accepted by his family. The return of an aged spouse usually does not present any problem. On the contrary, his or her return may have been urged and eagerly expected. The social worker advises the family, in advance, about the symptoms of disease and handicaps that have to be expected when a person who underwent an amputation, suffered a paralytic stroke, lost his speech, is unable to feed or bathe himself, or incontinent, returns home and becomes again a member of the household.

Not a few of the patients with chronic illness have been in the wards for such protracted periods of time that their previous living arrangements were discontinued. In selected, although not too many instances, a boarding home arrangement may be made by the Social Service Department as a substitute home for the homeless patient. Interestingly enough, former patients sometimes offer their homes for such purposes.

The situation is more complex when transfer to home care involves moving into a new family setting. Many an aged person may well have managed to live alone before chronic illness required hospital care. Life in a furnished room may, in spite of its inherent inconveniences, seem preferable to the alternative of moving in with a married child and sharing the unaccustomed pattern of their family life. But when such a move becomes necessary in view of disability and need for attendance, then psychologic problems may be anticipated. They are carefully evaluated by the social worker, and her judgment is of weight in the final decision.

Length of Stay at Home

There is no limit to the length of time patients may remain on home care. The continued clinical need for this type of care and the continued availability of adequate home conditions

are the criteria for continuation of care. The situation is reviewed at intervals by the team of medical and social workers. If necessary, other plans are worked out with the patient.

The 904 aged chronically ill persons on home care on May 31, 1953, may be divided into 2 groups (table 3). For one group, comprising two-thirds of this patient load, the present episode of home care was the first such experience; they had been on home care without interruption since transfer from the ward. Approximately 200 of the 600 patients in this first group were on the home care regime less than three months prior to the date of the census, but 154, or more than 25 per cent, had been on home care without interruption for a year or more.

TABLE 3. AGED PATIENTS ON HOME CARE, BY LENGTH OF TIME, WITHOUT AND WITH INTERRUPTION.

Length of Time		*Without Interruption*	*With Interruption*
Less than 6 months	363	317	46
6 to 12 months	192	130	62
One year and more	349	154	195
Total	904	601	303

The other group, accounting for one-third of the 904-patient census, had been transferred back to the ward for intermediate care one or more times. Two out of 3 patients in this group had started on home care more than a year prior to the census; some of them two and three years previously. In the interim they had returned to the ward from 1 to 6 or more times. Patients who require 6 or 8, or even more, retransfers to the hospital are far from the rule, but they are no rarity. The duration of the respective episodes is closely watched. When the periods on home care become shorter and those in the wards become longer, the patient's medical care program is re-evaluated; protracted or permanent institutional care may become necessary.

SUMMARY

The Home Care Service of the Department of Hospitals of New York City is a program for indigent patients of all age groups who need long-term care, although approximately half of the patients using this service are 65 years of age or older. Patients on home care retain their status as hospital patients and may be transferred back to the hospital ward as often as necessary; no limit is placed on the duration of home care.

Before transfer from ward to home care a thorough medico-social evaluation is conducted. The requirements are discussed.

125 Worth Street, New York 13, New York.

ACTIVITY PROGRAMING FOR RETIREMENT BY EXECUTIVES

HAROLD R. HALL, M.B.A.

IMPROVED activity planning for retirement by the relatively few executives in this country would aid countless others and at the same time bring a larger measure of happiness to most of the executives themselves. Here is a situation in which so few could do so much for so many.

Extensive interviews with more than 500 executives—some retired, some still at work, some from large firms, some from small firms —form the basis for these observations and those to follow.

Executives can contribute to their organizations by establishing confidence in the so-called "retirement" period by 1) preclusion or reduction of let-down in job accomplishment the last year or so before retirement dates; 2) example setting to those below them of the advisability of sound retirement preparation; and 3) the ability and desire to talk understandingly with others who need help on the subject.

From the point of view of executives themselves there is the important question, "What shall I do after leaving my long-time career job?" Answering that question wisely and specifically is the most important yet neglected task that approximately 4 out of 5 executives face as they plan ahead for retirement. In fact, not having an adequate *activity* program ready when "R day" comes may nullify, in whole or in part, the success of retirement for which there has been good *financial* preparation. More dissatisfying retirements have resulted from this cause than from insufficient financial means.

Only a minority, amounting to about one-fifth of top-management and middle-management executives approaching retirement, may have no need to be concerned with advance activity planning. In this group belong the small number of men who have always been abnormally lazy, driven by the necessity of taking care of their families rather than working willingly. Less rare are the men who have always disliked their particular jobs for any number of reasons and will get a continued feeling of relief out of retirement. But the individual cannot rely on his own feeling that he belongs in such a category, it is all too easy for him to deceive himself.

Then there are others in this small minority group who, along with their wives, are social-minded to such an extent that predominantly social activities with chosen friends apparently suffice in retirement, at least for awhile. There are also the lucky few, who are usually top-management members of sizable organizations, in such a position that they can count on demands for their services in other business and/or nonbusiness pursuits after retirement.

In a different category are the executives who have been subject to especially heavy pressure or burdensome responsibility during the last few years before leaving their organizations. These men may experience sufficient release to offset the need of activity for a while but they are likely later to tire of inactivity or substitutes for problems and to start trying to find some useful work to occupy their time.

The large majority, or remaining four-fifths, of active executives *must* do something about an activity program if they are to be as happy as most of them expect to be after they leave their companies. I am assuming continuance of reasonably good health, which is obviously prerequisite.

Of course, most executives approaching retirement realize that they need something to do for their retirement days or at least suspect that such is the case. A large proportion, however, fail to recognize their need for problems to challenge and hold their interest after they

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have left their companies. Many believe, or hope, that relatively inconsequential things will adequately satisfy them. More active company executives should talk with retired men on this point.

Based on my study, a large majority of older executives still in business have not formulated a careful and thorough program for the activity part of their retirement, nor had most retired executives done so before they left their companies. And apparently in but few instances does any non-family person worry or offer help if the job does not get done. There was much evidence that the wives made suggestions. In fact, the impression was gained that several well-rounded activity programs had come into being primarily from the wives' influence.

In only 4 instances did discussions with retired executives bring out the point that their companies had an arrangement designed to stimulate the executives' thinking about their individual retirement preparation. One of these men, formerly the executive vice-president of a large organization, said he thought such "help to help one's self" would—and should—grow. He pointed out the following:

> "By the very nature of most company retirement plans, executives are asked to leave their organizations whether or not they want to do so. To all employees who are under that requirement, management has an obligation to offer some form of help with activity preparation for retirement, just as it does with the financial aspect in the form of pensions."

Why do most executives fail to face up to a thorough job in their activity preparation for retirement? To a large proportion, the task seems unnatural and unpleasant. So they delay and delay. After a while the only answer seems to be that they must manage somehow not to be retired. Many men then develop the hope, which they almost rationalize to the point of believing: "Surely the company won't do it to *me*."

Another reason on the part of many executives seems to be the feeling that they are sufficiently equipped if they have some general ideas of activities in mind. Here are a few comments made along this line. Each represents a retirement program in the opinion of the man expressing it.

> "It seems to me that retirement should mean doing just what a fellow wants to do at a pace he enjoys, being governed only by the amount of money he can afford to spend."
>
> "Relief from pressure will be a lot in itself; choosing friends with whom my wife and I want to spend time is another advantage; and the chance to read all I want appeals to me greatly."
>
> "Why, there must be more than a thousand books that I want to read; let's say I finish two a week, there's about ten years by itself!"
>
> "We'll want to do a good deal of traveling—among other reasons, so that we can get better acquainted with the grandchildren; and my wife and I both like to garden and work around the house."
>
> "If it can be arranged, I would like to work about half the time and use the other half for whatever we want to do, including some traveling."

There is clear indication that ducking the job of programing for retirement not only makes getting it done more difficult as time goes on but also usually adds to adjustment troubles. Discussions with retired executives brought out also the information that difficulties seemed even greater when a man realized after retirement that he had placed false reliance on programs that were too general.

As a reason for not working on an activity retirement program other men make a remark such as, "At the pace I am going I'll never live to retirement age anyway." Despite the fact that there is no way to estimate the age at which any individual will die, there is a good deal of useful information in the "averages" which are, of course, what life expectancy tables really indicate. Based on the experience of white males in the United States during 1949 the executive's chances of reaching age 65 may be well approximated. At 40 years of age he has almost a 70 per cent chance to live to 65, at 50 about 75 per cent, at 55, 80 per cent, and at 60 years of age, over 85 per cent chance to live to age 65. Moreover, these same data published by the National Office of Vital Statistics indicate that of all men reaching 65, more than 80 per cent will live to 70 and almost 59 per cent will live to 75. Some executives seem to

rationalize that they are simply on the wrong side of these averages—and they are usually not being facetious about it.

There is not space to discuss other aspects of activity preparation by executives. Those who are interested in expansion of the subject may wish to read, "Plan Your Retirement Activities Early" (1).

Perhaps the best way to summarize the positive approach to activity preparation for retirement by executives is to list what might be called "Guides to Success." The evidence gained regarding many successful and unsuccessful retirements provides the basis for the following suggestions.

1. Guard and nourish your health and get your wife to do likewise. In retirement the point is emphasized that this world is made for well people. Serious illness on the part of a man or his wife is bad enough at any time but seems even worse if the couple cannot carry out an activity program they have studiously planned together.

2. Consult with your wife from the start and during activity planning. Unless specific activity plans and the location in which they will take place are thoroughly agreed upon in advance, the members of the retired team are probably in for trouble.

3. Be sure the costs of retirement living and activities are conservatively within your financial ability to support them. Large and precipitous cutbacks in the standard of living can be a basic cause for much unhappiness. Budget more for the first year, however, than you have in mind for succeeding years, even to the extent of some inroad on capital or the withdrawal of the cash value of an insurance policy.

4. Plan an active life both mentally and physically but paced to suit the desires and well-being of each member of the team. Since it is difficult to know in advance exactly how to carry out this suggestion, include some flexibility in your activity program. It is usually better to plan too much than not enough. Moreover, some margin is advisable for proposals that may not be practical or those that turn out to be not as interesting as anticipated.

5. Unless you decide that a full-time job is what you want—and can get in advance of leaving your company—include a number of part-time activities in both work and play. Variety adds to interest and satisfaction. Moreover, a mixture of work and straight recreation seems to add zest to both.

6. Become a member of some organization team which you respect and to which you feel a special loyalty. Many retired executives said they had not previously appreciated fully the satisfactions from being a member of their company team. They stressed the stimulation from working with team members and the value of being of real service to the team. Replacement of these satisfactions is especially needed.

7. Include some work that brings a degree of pressure and resulting tension with it. This may seem a strange suggestion in connection with retirement time. But the circumstance seems to be that executives have become so used to business pressure that the need for a minimum of tension remains in the system after they leave their companies.

8. Include among prospects for retirement activities the non-business pursuits with which you have had experience but consider only those that you have really enjoyed. The spirit of retirement removes the sense of duty that may have motivated some non-business pursuits. Be sure any elections are genuine interests, not just tasks that carried little more than a sense of relief when they were completed.

9. If you do not have in your program work which includes gratification from doing for others, determine a new assignment of this nature. Plan at least one such job wholly without monetary return. Many retired executives mentioned the value of this suggestion. Their explanation usually carried no sentiment with it; whatever the reason, they were convinced that the idea worked.

10. Seek in the over-all program at least one new activity, preferably involving suspected skills. There is no better way to prove to one's self that old dogs can learn new tricks than by insisting on a demonstration of the point. And confidence in other activities is

built from this self-proved conclusion.

11. If you have a well-developed hobby or hobbies, by all means include such in your program. Hobbies that stress creativeness seem to be particularly valuable. Most retirees reported, however, that relying on hobbies alone for retirement does not bring full satisfaction. One retired man said, "For me hobbies are like desserts, I have to have some meat and potatoes of work for my main fare."

12. Try out in advance at least the important aspects of your retirement activity program. Active executives reported that ways can be found to do this. Vacations were used for some types of exploration and business trips provided opportunities. Many men viewed civic and charitable jobs as a way to size-up and select assignments for post-company activity.

13. Consider as natural the doubts and fears that may arise in connection with your retirement program. Go about eliminating them through the use of good judgment and the power of decision. Remember that important moves in your long-time career also brought doubts and fears. Retiring from your company is another important move, no more than that, so you should not let it throw you.

14. If you want to take a "long trip" or a "deserved and desired rest" at the start of your retirement period be sure important elements in your activity program are tied down beforehand. Many men emphasized the desirability of making certain that retirement activities associated with business should be arranged while one is still a full-fledged member of the business community. In addition, it should help to realize that you can return home and have some work to do.

15. When it is time to implement your program, do so promptly and enthusiastically for delay is a hazard to peace of mind. Adopt a positive attitude toward the new venture which is designed to round out the lives of your wife and yourself together with chosen opportunities for accomplishment, satisfaction, and fun.

The individual activity programs resulting from the foregoing suggestions will nearly always include more than one activity perhaps even to the extent of overlapping. It is clear from exploration and study that most successful activity programs are indeed those that call for a variety of things to do.

Plainly, the programs that lie within the resources and the needs of various executives are bound to differ. But ingenuity and resourcefulness industriously applied can bring about a wholly adequate activity program as well as pleasure in constructing it.

Summary

About one-fifth of executives may not need activity programing for retirement. In this group are men who have always been abnormally lazy, those who have always greatly disliked their jobs, or who have been subjected to especially heavy pressure a few years before retirement, and a relative few who can count on demands for their services after they leave their companies in business or nonbusiness activities.

At least four-fifths of executives need a carefully prepared program for the retirement period of their lives. On the other hand, a large majority do not arrange an adequate program of this kind.

The primary reasons for lack of preparation or incomplete programing are:

1. The task seems unnatural and unpleasant;
2. The men are satisfied with a program that is too general;
3. They either believe the chances of living long enough to use a long-time program are small, or use that view as an excuse.

The positive approach to activity preparation for retirement is covered by 15 "Guides to Success" based on evidence obtained from the study of actual successful and unsuccessful retirements.

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Wellesley Hills 82, Massachusetts.

A PROGRAM TO PREPARE COLLEGE TEACHERS FOR RETIREMENT

GEORGE E. JOHNSON

(Teachers Insurance & Annuity Association of America and the College Retirement Equities Fund, New York)

A program to prepare for retirement is a program to prepare for a second career. This second career can be exciting, interesting, and satisfying if preparation is made to cope realistically with changing conditions; it can be a nightmare of fear and frustration if it is not made. Preparation is as essential for a retirement career as for a business career.

The basic foundation of preparation for retirement is the establishment of a good plan for an income adequate to meet our needs in later life. But just as the foundation is not the whole house, so an income, even though generous in amount, is not alone sufficient. Many wealthy individuals make poor adjustment to retirement. We must prepare to meet many problems in addition to the financial ones.

The Test of a Good Retirement Income Plan

How does one identify a good retirement income plan or pension system? There is one simple test that anyone can apply which goes right to the heart of the matter—does the plan meet the basic needs of the participants for retirement income? In a nutshell these basic needs are for an income adequate to care for the participants and their dependents when, because of old age, disability, or death, they can no longer earn the necessary income from personal efforts.

How to Improve College Retirement Income Plans

College retirement income plans have been improved greatly in recent years and have many merits. They compare favorably with those in industry. But let us apply the "needs" test to see how improvements can be made in some college retirement income plans.

(a) *The plan should be fully funded.* College administrators are often not completely aware of the funds needed to support a retired person. Fortunately the trend has been away from unfunded plans, and there are relatively few unfunded college retirement plans today.

(b) *The plan should be fully vested.* A man's need for income is precisely the same whether he works for thirty years for one employer or for ten years for each of three employers. If in moving from one employer to another he forfeits a part or all of his retirement benefits, the plan does not meet his basic need for retirement income. Furthermore, in the college world at least, there is an obvious advantage in encouraging the free mobility of academic talent from one institution of higher learning to another. Most privately endowed colleges have fully vested retirement plans using the contracts of the Teachers Insurance & Annuity Association. Most publicly supported institutions, however, have forfeiture plans.

(c) *The retirement income should correlate with the cost of living.* In the past most retirement plans have provided for pensions payable in a fixed number of dollars. These plans do not meet the "needs" test since they do not meet the need for increased purchasing power during a period of inflation. The retired man must convert his pension dollars into the necessities and comforts of life. Thus he needs a retirement income which will vary as the price level changes. Recently many colleges have attempted to deal with this problem by funding pension contributions through the Teachers Insurance & Annuity Association (TIAA) and

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the College Retirement Equities Fund (CREF). Under this combination a part of the annuity is payable each year in a fixed number of dollars which have greater purchasing power in times of deflation and less purchasing power in times of inflation. Another part of the annuity is payable in "units" rather than dollars. These units are worth more in times of inflation and less in times of deflation. Thus the two parts complement each other and act as a hedge against each other. Detailed economic statistics show that in combination they should correlate closely with the cost of living.

The combination of TIAA and CREF became available on July 1, 1952. Since then nearly 350 colleges and other educational institutions have revised their retirement plans to take advantage of it. While this method of providing a variable annuity is new, and to that extent untried, it offers real possibilities of correcting one of the major weaknesses of past retirement plans.

(d) *All colleges should have Federal O.A.S.I. coverage.* While most privately endowed colleges have Federal OASI coverage as a result of the 1950 amendment to the Social Security law, most publicly supported colleges do not. Through a very unwise provision in the 1950 amendment they are, in effect, barred from Federal OASI coverage unless they cancel existing pension plans. Naturally most of these publicly supported colleges have been reluctant to cancel existing plans, fearing that the state legislature will take this opportunity to reduce the pensions promised under the local plan. Since this limitation, contained in Sections 218(b)(4) and 218(d) of Title II of the Social Security Act, serves no useful purpose, it is to be hoped that the barrier will be removed soon.

(e) *Better nonmedical life insurance plans are needed—especially in the publicly supported colleges.* Few colleges have adequate collective or group insurance plans, and the employees in most publicly supported colleges suffer by comparison with the privately endowed colleges on two counts. The former do not have the benefit of the substantial amount of insurance included in Federal OASI coverage, and only a handful have any form of collective or group life insurance.

(f) *Colleges should provide adequately for the teacher who becomes totally and permanently disabled while teaching.* The colleges have made little headway in this area. Much needs to be done.

Income Maintenance in Addition to Pensions

Sometimes the fact is overlooked that the maintenance of an adequate income after retirement is not limited to pensions and widows' benefits. A recent study of TIAA annuitants showed that the average age for retirement is approximately 67. Another study showed that a large proportion of our annuitants had earned substantial incomes in the preceding year. Retirement from a job is not always retirement from work. For many persons a program of preparation for retirement includes a program to continue personal earnings at some level for a long time.

A number of retired teachers have learned to type for the first time. The acquisition of this manual skill not only provides them with a facility no longer available from a secretary or typist at the college but also gives them a lift and inspires a certain measure of confidence in their efforts to tackle new things.

At the present time many colleges are helping teachers obtain work after retirement either on a part-time basis at the college or at some other institution. This work should be continued and extended. Employment of college teachers after retirement would be greatly aided by the establishment of a centralized placement bureau. After retirement many teachers continue to teach either full- or part-time. Some teachers write books or perform other services for which they earn money. Sometimes they work on the campus but often they work elsewhere. A centralized placement bureau would provide one place where all older teachers who want to continue their professional careers could register and where all

colleges that want to tap this reservoir could apply. This bureau could constantly strive to find positions suited to the specialities and capacities of older teachers.

At the present time if a college wants an older teacher with specific qualifications it must often write hundreds of letters. Sometimes these letters are received by unsympathetic or harried college officers or deans rather than by teachers themselves. If there were a central agency to put the teachers and the colleges in touch with each other, much time and effort would be saved.

It is interesting to note that the John Hay Whitney Foundation initiated in January, 1952, a program, comprised of two parts, for retired professors in the humanities and social sciences. The first, the six annual Whitney Visiting Professorships, provides that each awardee who receives a grant from the Foundation spend an academic year teaching and counseling at an independent liberal arts college. In the registry of retired professors, the second part of the program, the Foundation hopes to include all persons who have retired recently in the specified fields and will provide suggestions upon request from colleges and universities that are in a position to finance such an appointment themselves.

Experience at TIAA has shown that placement at the higher ages is sometimes made difficult or impossible by the unwillingness of a teacher to accept work which he thinks is beneath his dignity, whereas it is often relatively easy for a retired teacher to find work if he is willing to adjust to available openings

Encouragement of thrift also helps the teacher meet the income maintenance problem. Many colleges encourage thrift in a number of ways. The business officer will sometimes arrange to deduct a part of salary:

(a) to pay for life insurance. Most of these life insurance policies contain settlement options which may be converted into annuities or into cash emergency funds during the retirement period.

(b) to apply as a premium on a TIAA collective life insurance policy which does not terminate upon retirement. The teacher can continued this nonmedical form of insurance even after retirement by paying the same premium on an annual basis and without a medical examination, and thus help meet the income needs of his dependents.

(c) to apply as a premium on an annuity contract.

(d) to purchase U. S. bonds automatically.

(e) to deposit into a savings bank account. Teachers authorize monthly deductions of a certain amount, perhaps $25 a month. The business office has custody of the bank books and, once a month, the books are sent to the bank together with one check. An accompanying list enumerates the deposits to be made to the various accounts. After entering the deposits the bank returns the books to the business officer. If the teacher wants to make a withdrawal, he may request his book at any time.

Problems Other Than Income Maintenance

While the foundation is important to the building, the building itself should not be neglected. All too often colleges have concentrated on the retirement income plan to the exclusion of other important parts of a complete program for retirement. Many persons with adequate retirement income make poor adjustments. Therefore, apart from the income maintenance problem, a good program of preparation for retirement in the colleges should also cover these areas: health maintenance, education for adjustment, counseling, summer institutes, and retired teachers clubs.

1. *Health maintenance.* Many colleges with good medical facilities on the campus make no effort to promote periodic medical checkups among the faculty, or otherwise engage in preventive medical practices. Many large industrial concerns now have excellent medical departments and furnish nursing and dental services as well. In many colleges the students are

encouraged to take advantage of the medical facilities and sometimes the children of teachers are similarly encouraged. But although the faculty is the most important asset of the college and the most expensive to replace, the faculty members, especially the older ones, are seldom included in a health maintenance program. This is an anomalous situation since the *need* for medical attention increases with the age of the individual. The total cost to the college of providing such preventive medical services for the faculty would be small in proportion to the total salary paid to the college teaching staff. If industry after careful studies has concluded that industrial medicine or preventive medicine pays off in dollars and cents, why should not a college also study the feasibility of preventive medicine for the benefit of its staff—especially since it must maintain medical facilities for other purposes?

2. *Education for adjustment.* Teachers are well aware of the need to continue education and learning throughout their lifetime. They will therefore see the need of special education to meet the new conditions and problems they will face after retirement. There are a number of simple ways by which this education can be furnished:

(a) *Magazines.* Today there are some good, general magazines especially designed for retirement, such as *Lifetime Living* and *Journal of Living.*

Colleges may want to follow TIAA's example. TIAA offers to pay for a subscription to either magazine for its office staff members over 40 years of age. The adoption of this one suggestion is a major step forward as it gets the staff members thinking about a career after retirement while he is in his middle years. Since the magazine is sent to the home address, it is available to the man and his wife. Thus they are both encouraged to think in a constructive way about the life they may expect to lead in later maturity.

A few colleges have general college magazines or alumni magazines. These magazines could carry occasional articles on the preparation for retirement. Articles based on the actual experiences of people in retirement are often extremely interesting.

(b) *Libraries.* Many colleges have fine libraries, but often there is no separate index to the material on preparing for a career in retirement. The many excellent popular books on this subject could be made readily available by the college library and could be brought to the attention of all teachers. Some colleges may want to put such books in the faculty club library or on a circulating library basis.

(c) *Pamphlets.* There are some excellent pamphlets and leaflets available for distribution. These cover preventive medicine, hobbies, avocations, places to live, and allied subjects.

(d) *Courses of instruction.* Interest in designing special courses for older persons is growing rapidly. The University of Chicago has a home study course administered through its home study department, entitled Making the Most of Maturity. The University states that this is a program for adults who want to enjoy their later years by making the best possible use of their resources—physical, mental, financial, and social. The University of Michigan has developed successful lecture courses and more lecture courses of this type are being designed.

Recently TIAA tried an experimental course, conducted as a round table discussion, for all employees over 55 years of age. Available material on the subject was brought to the attention of all participants, and they were encouraged to begin thinking about their special problems. The participants enjoyed the free, frank discussion that developed and thought these meetings stimulating and interesting. In group discussions of the common problems of later maturity, the door was often opened to specific suggestions or counseling on personal problems.

3. *Counseling.* Many industrial concerns are now experimenting with preretirement counseling programs. These programs sometimes provide for a schedule of several interviews be-

tween the personnel office and the worker, starting about five years before the normal retirement date. For example, a company may provide for four interviews scheduled as follows: first interview, five years; second interview, two years; third interview, one year; fourth interview, two weeks before retirement.

There is no reason why a similar program of interviews and counseling should not work in the college field. By having an established college program, much of the emotional sting of approaching retirement would be removed. The teacher would not imagine that the administrative officers had singled him out for certain reasons and that the retirement skids would be put under him.

4. *A two-week summer institute.* Colleges are almost ideally situated to conduct a special two-week summer institute for older teachers and their wives. A small college campus amidst pleasant surroundings might offer the best facilities, since attendance at the institute might well be a substitute for a vacation. Such an institute might consist of lecture courses followed by group discussions. Where medical facilities are available, a physical checkup for every person attending the institute might be possible.

The fee for attending such an institute should not be excessive since the college could afford to set a low charge for the use of vacant dormitories and classrooms during the summer vacation period. The teacher might find that the fee was no greater than his expenses for a two-week vacation.

Much of the time would be spent in seminar work and group discussion, which should stimulate the participants to think and plan ahead and help them to grasp the concept that retirement is a graduation to a new life rather than a casting-out process.

5. *Retired staff clubs.* In some industrial firms special clubs have been set up. These clubs usually work with a "twenty-five year club" or some other existing club based on a long period of service in the firm. Colleges will undoubtedly follow their lead.

Pennsylvania State College has maintained a retired staff club for several years with fine results. Among other things this club is developing a fund to help any retiree who faces an emergency. The club brought to the attention of the authorities the desirability of recovering retirees who had been dropped from the hospitalization plan. One committee follows the course of legislation at the state capitol as it affects retirees. Another collaborates with the president's office to find positions retirees can fill in order to augment their pensions. Recently the retired or near retired faculty members at the University of Michigan formed the University of Michigan Annuitants Club. They have a steering committee of nine active men and are undertaking to inform themselves on gerontologic matters. Clubs of this sort will undoubtedly spring up at many colleges and universities.

Summary

Preparation for retirement begins with provisions for income maintenance. On the whole college retirement income plans have been greatly improved in recent years and meet the needs of the teacher for adequate retirement income. Few, however, have any provisions for income in the event of total and permanent disability, and some have these weaknesses: they are unfunded, they are not fully vested and thus involve forfeiture of benefits upon termination of employment, they do not provide for a variable annuity correlating with the cost of living, they do not provide Federal OASI coverage as the underlying basis of protection, and they do not provide nonmedical life insurance for the protection of dependents.

Income maintenance involves more than a retirement income plan. Much can be accomplished by the establishment of a centralized placement bureau and other means of helping teachers continue their professional careers after retirement and by the encouragement of thrift through the use of salary deduction techniques.

Turning from the problem of income main-

tenance to an area of preparation which has been frequently neglected: (a) colleges would profit from the experience of industry by establishing better health protection for their staff members, e.g., by providing periodic medical checkups; (b) college staff members should be encouraged to think about problems of later maturity by being encouraged to read magazines, books, and pamphlets on this subject and by arranging for and attending special courses relating to life in later maturity; (c) systematic interviews and group counseling methods should become more common; (d) a 2-week summer institute would have many advantages; and (e) retired staff clubs should be formed at many colleges.

522 Fifth Avenue, New York 36, New York.

AGING AND COMMUNITY HEALTH PROGRAMS

LESTER BRESLOW, M.D.

(From the Bureau of Chronic Diseases, California State Department of Public Health, Berkeley)

COMMUNITIES have long recognized the fundamental importance of health maintenance programs. The dependence of our cities upon preventive health services comprises a basic chapter in modern history. In order to maintain the large population groups needed for factory production in the crowded living arrangements of industrial communities it was necessary first of all to control communicable diseases. As long as periodic waves of cholera, smallpox, plague, and similar diseases threatened the urban population, industry could not develop with assurance of an available labor force. The modern city could not be stabilized. Faced with this problem of survival, our early industrial civilization developed the means and organized programs to combat the epidemic diseases.

In the course of well-known achievements in controlling the diseases which endangered the very existence of industrial life, communities found that haphazard effort did not suffice. They developed public health, "the art and science of preventing disease, prolonging life and promoting physical and mental efficiency through organized community effort" (3).

At the center of this organized community effort in the United States, one finds the health department, which serves as the core of widespread community activity, including the several health professions, voluntary health agencies, hospitals, and other health resources. Advances in the health of our people have resulted in no small part from the organized community effort represented by the health department and its allies.

Now our communities face a new kind of health problem—the health of an aging population. As we grow in years we do not suffer diseases which are essentially different from those in younger life, but the effects are often more severe. This is true because we lose some of our constitutional resilience in later years and also because of the generally less favorable environment which is the lot of older people. Aging people are particularly subject to cancer and to several progressive diseases of the vascular system, the nervous system and sense organs, and the internal glandular system. These and other conditions lead to more frequent and more prolonged periods of disability than occur among young people. The well-known deterioration of socio-economic status in the later decades of life both results from and contributes to the burden of chronic illness. Much more could be said in description of the problem. Perhaps one could summarize by quoting two sentences from the report of the recent President's Commission on the Health Needs of the Nation, "Our aging population reflects health progress and yet, paradoxically, manifests some of the greatest health needs . . . (and) . . . In general . . . health services are woefully inadequate in quantity and quality for the aging, wherever they may live" (1).

What shall we do about the health of our aging population? As gerontologists we recognize that what we do about it must be related to our total effort in behalf of the aging —to our policies regarding their employment, retirement, housing, recreation, and many other aspects of their life. But what specifically shall we do about their health?

At present we do not have much organized community effort directed toward improving the health of the aging. We limit ourselves largely to institutionalizing those aging individ-

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uals who suffer from the most severe forms of disease.

This is not a unique approach to a major health problem. In times past our first efforts to control the fevers, tuberculosis, and mental disease took the form of hiding the evidence. In each case we tried to put the affected individuals out of our sight and thus forget them more easily. Then we began to realize that these health problems arose out of community life, that they might affect almost any individual in the community. Finally we went out into the community to attack the problem as close to its roots as possible.

We seem to be following the same pattern with respect to the health problems of the aging. We discharge whatever community responsibility we feel toward them by putting the most severely affected individuals away in almshouses or other inadequate public institutions. To an alarming extent recently we are sending them to mental institutions. Tens of thousands of aging people in this country each year are shipped off to state mental hospitals for custodial care. Many of these people do not have mental conditions warranting admission to a mental institution and little can be done there to help them return to their homes.

Certainly some health needs of older people ought to be met by institutional care. Here and there around the country a new type of institutional care is emerging—a type which is really aimed at meeting these needs, a type which includes genuine rehabilitation, not merely custody, a type which extends itself into home care. But thus far our efforts at institutional care—with a few brilliant exceptions—seem to be haphazard approaches to the total problem. We still for the most part hide the evidence.

And even the best organized program of care in hospitals and related institutions does not comprise an adequate community health program for the aging. Rather we must develop ways of attacking the problem more aggressively. We must go out into the community, as we have learned to do in the case of tuberculosis, with organized effort to prevent individual breakdown from disease and to help maintain health among those who are well.

Certain trends in this direction are beginning to appear. Some community health services once directed primarily toward the needs of children and younger people are being oriented toward the needs of older people. Public health nursing service, both that sponsored by Visiting Nurse Associations and that organized in health departments, is increasingly being called upon to aid older people. Heart disease and cancer appear in public health nursing records more frequently, diptheria and whooping cough less frequently, than in years gone by.

One of our outstanding public health activities—tuberculosis control—is now being concentrated on older people. As this once terrifying disease regresses, we find it limited more and more to elderly men. Hence, our tuberculosis control program emphasizes this group rather than the younger people who were heretofore the principal focus of control efforts.

The entire gamut of community health services shows some evidence of beginning realignment to meet the health needs of an aging population. But this realignment is still tentative. Scarcely anywhere does one find a full commitment to the idea.

Why is progress in this direction so slow and seemingly unorganized? In answer to this question one could take refuge in the easy generality of lag in social change. However, at least two specific notions seem to be holding up advancement on this health frontier. Both of these deserve some analysis.

One widely-held notion is that disease processes of the aging are inevitable, that nothing really can be done about health among the aging, except perhaps to furnish custodial care. This idea often finds expression in the term "degenerative disease." According to this concept, arteriosclerosis, cancer, neuro-muscular diseases and the other pathologic conditions common in later years represent inevitable concomitants of the senescent period. In this connection it may be recalled that less than a hundred years ago prevailing opinion held tuberculosis to be a degenerative disease oc-

curring in certain families. We use no greater logic today in calling arteriosclerosis, cancer, and neuro-muscular diseases degenerative than did our forbears in using this term for tuberculosis a couple of generations ago. The term bespeaks only ignorance and defeatism.

In a period of rapid scientific advances such as the present, we should be especially alert to every possibility of acquiring and applying new knowledge; we cannot tolerate ignorance and defeatism about our health problems.

An example may serve to illustrate this point. Men of this country over 45 years old, it is well known, die largely of diseases which some people call degenerative, e.g., arteriosclerotic heart disease. What is not so well known is the fact that men in the United States die of such diseases at a very much higher rate than do men of other countries. At age 45 to 49 years, and at every 5-year age period thereafter up to 80 years of age, United States men (white) die at a substantially higher rate than do men of Sweden, Norway, Netherlands, New Zealand, Canada, and other countries (2). For every 100 men of the United States who die at age over 45 each year, only 60 to 85 men in these other countries die. (These figures take into account the age distribution of the population in the various countries.) This excessive mortality in the United States arises largely from deaths caused by the cardiovascular-renal diseases. Study of trends within the United States also reveals a significantly increasing mortality from this cause among men in this country since 1920.

Shall we conclude then that American men are "degenerating" today more rapidly than do the Scandinavians and Dutch, and more rapidly than did the last generation of Americans? Or shall we examine environmental circumstances and our way of life to find an explanation for these differences? Our national superiority in health, in which we have justifiably taken so much pride, now falls off sharply at age 45 and beyond.

Clearly the notion that diseases of the aging are degenerative and inevitable must be rejected in the light of substantial national differences in the rates. Such a backward view not only interferes with the application of present knowledge for health maintenance in adult life, such as obesity control, it also impedes inquiry into better means of health preservation.

A second notion which seems to be retarding community health programs for the aging is the idea that community health services should be limited to communicable disease control. This view finds expression in such language as "If a disease isn't communicable, it's no business of the health department's." Of course, community health services of many types—including those for the aging—may (and should) be undertaken by agencies other than the health department. Voluntary health societies, the several health professions, hospitals, and other organizations play essential roles. But let us not avoid examining the responsibilities of the basic community health organization—the health department—for an aging population.

We are all aware of the achievements in communicable disease control and health advancement made possible by the functioning of health departments. Shall we stop there? Or, accepting the idea of community responsibility for a health program for the aging, shall we ask that our health departments turn their efforts systematically toward the major health problem of the day—the problem of chronic disease in an aging population?

Public health, in its successful attack on the communicable diseases, has developed many techniques and specialized personnel which seem useful in attacking the non-communicable diseases of later life.

Epidemiologic investigation helped us to unravel the secrets of typhus and pellagra; it has showed some promise but is far too little used against cancer and heart disease.

Early detection of disease through active case-finding has played an important part in our campaigns against tuberculosis and syphilis. The community organization techniques for early detection of diabetes are the same. And we have a simple, inexpensive screening test for diabetes which requires only a drop of

blood as the specimen. Good treatment early in the course of diabetes, and other common diseases of the aging which can be detected by screening, will prevent much disability and premature death. Should we not ask our health departments to utilize their experience in case-finding for help in the control of these diseases among the aging?

Mention has already been made of the public health nurse. She finds ready acceptance in American homes because families appreciate her concrete help in protecting them against the communicable diseases and aiding them to minimize their ill effects. Shall we ask the public health nurse when she visits a family to limit her attention to communicable disease problems? Or shall we expect her to provide a genuine family health service toward the problems of the old as well as those of the young, the non-communicable as well as the communicable diseases?

In health education we must continue to emphasize the importance of a good start for health in early life. But is it not time for health educators to devote greater attention than heretofore to the health practices of middle and later life? This applies to health educators in health departments as well as those in the voluntary health agencies concerned with special categories of disease.

Nutritionists in community health work, until recently, concerned themselves almost exclusively with food for young people. Now they are beginning to give substantial amounts of time to the problems of specific dietary deficiencies and obesity among older people.

Medical social service perhaps more than some other health services has long emphasized total family needs. The health problems of an individual—be they communicable or non-communicable—often involve an entire family and are then best approached as family health problems. Medical social workers in health departments have helped us to see the relationship of the family and the community to health problems, a relationship which is just as significant for the aging as for the young.

One could thus review every health department function and note how the services might be applied to the health problems of the aging. A community which recognizes its responsibility for the aging will surely look to all its resources in attacking the outstanding problems. Such a community will reject the notion that health department servcies should be restricted to the young or to those affected by the communicable diseases. Communities will find ways to utilize their present health department resources and expand them for the prevention of disease among the aging and for extending and maintaining healthful life.

Gerontologists, broadly concerned as they are with all aspects of aging, will undoubtedly play a prominent role in the development of community health programs for the aging. In this connection, one immediate responsibility is to emphasize the distinction between disease and aging, especially to help in conquering the harmful illogical notion of degenerative disease. Another urgent responsibility is to aid the development of community health programs through redirecting and augmenting the resources of health departments.

Summary

Gradually our community health services, including those of the public health department, are being reoriented to meet the needs of older people. Two concepts seem to be holding up programs in this direction. One is that diseases of the aging are "degenerative" and hence inevitable. The other is that community health services should be limited to communicable disease control. Both of these ideas are examined and rejected.

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2180 Milvia Street, Berkeley 4, California.

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Dr. J. Esben Kirk
Division of Gerontology
Washington University School of Medicine
St. Louis 10, Missouri

BOOK REVIEWS

REHABILITATION OF THE OLDER WORKER, Edited by Wilma Donahue, James Rae, Jr., and Roger B. Berry, University of Michigan Press, Ann Arbor, 1953, 200 pages, $3.25.

In 1951 the University of Michigan held its Fourth Annual Conference on Aging devoted to the topic of rehabilitation of the handicapped worker over 40. This volume is largely the result of the conferences, workshops, and panel discussions which were held during that conference. In addition special chapters were contributed by John L. Thurston, Howard A. Rusk, James W. Rae, Jr., Lionel Z. Cosin, and Frank H. Krusen. Some very eminent authorities contributed comment and opinions. They were representatives of the Veterans Administration and of the former Federal Security Agency, some state vocational rehabilitation officials; plus such personalities as Nila K. Kovalt, Henry H. Kessler, Eugene J. Taylor, Daniel G. Blain, James F. Garrett, Josephine J. Buchanan, and others, including representatives from labor, from social work, and various other sources. Conferences were held on medical aspects of rehabilitation, on psychosocial and economic aspects, on employment and placement, and on rehabilitation services and programs. There was much discussion on the integration of efforts of social agencies, on the problem of compensation and its effect on rehabilitation, on the problem of industry in employing the handicapped, and on training and recruitment of rehabilitation personnel. One of the features of the book which adds a quality of spontaneity and freshness is also a definite disadvantage: that is, the almost verbatim recording of extemporaneous talk at the conferences. The result of this practice was to introduce the inevitable time lag before the volume was printed and to give a slightly dated character to some of the illustrations cited by the speakers.

This book, like all similar volumes I have consulted, was a disappointment to the reviewer. It not only does not solve any problems; it does not even suggest how solutions might be found. I am competent to discuss in detail only the sections on medical rehabilitation and in these I found nothing but repetition of previous pronouncements on the subject. The book is too general to be useful as a source volume. I suppose that every rehabilitation worker should own a copy although it will look strangely like programs and agendas of a dozen similar regional or national conferences. I do not think it will interest very many physicians in either rehabilitation or geriatric rehabilitation and I am afraid it will not touch many industrial concerns or their personnel managers.

As a physician I am inclined to regard the problem of rehabilitation of the older worker merely a part of the larger problem of employment of the physically handicapped. I do not believe that we have very many brilliant examples of vocational rehabilitation to demonstrate which were not achieved mainly through the efforts of the handicapped person himself. Until we are able to show considerable numbers which have gone back to employment or to minimal dependency through the efforts of social agencies and rehabilitation centers we shall not interest either physicians, the general public or industry.

S. MEAD
Department of Physical Medicine
Washington University
School of Medicine

OLDER PEOPLE, Robert J. Havighurst and Ruth Albrecht, Longmans, Green & Co., New York, 1953, 415 pages, 75 tables, $5.00.

The authors' aim "is to broaden the understanding of what it means to be old and to throw light on the factors that favor fulfillment and personal adjustment in the older years." It is about equally divided between a general overview of the conditions of life of older people in the United States and a technical study of the lives of older people in a small Midwestern city.

Part I is organized around the special problems of the aging, drawing its basic facts from the technical study in Part II. It discusses the special problems of older people: those distinguished from the general problems of all adults, and those unique old age aspects of the normal problems of normal people of all ages.

Among the special problems discussed are: physical helplessness, poverty, the feeling of rejection, loss of spouse, and loss of work. Although many older people escape these special problems, no one can escape the unique life changes common to all as he ages. These, labeled by the author as "the insults of aging," are: loss of physical attractiveness, lessening of physical health and vigor, and loss of status. The causes giving rise to the special and unique problems are three: changes in the body that undermine self-appraisal and reduce physical vigor, changes in the human environment, such as loss of spouse and friends by death, and loss of work by retirement or dismissal; and attitudes of society toward older people.

Subsequent chapters explore the attitude of society toward older people; happiness, health, economic se-

curity; work, leisure, family and living arrangements; friends and clubs; religion, citizenship, and education; and a personal, social philosophy of old age.

The principal sources of information for the book came from the case study of the Midwestern city reported in Part II; studies of older people in Chicago made over a peirod of years by the University of Chicago staff; census and other Government data; questionnaires used in earlier studies and administered again.

Part II, "The Elders of Prairie City," is based on a study of the broad, social characteristics of all the older people (those over 65) in Prairie City, and a more extended knowledge of a small sample of 100 persons interviewed by two people living during the study in the community.

The instruments used in the study, described in the appendix, were a questionnaire to study public opinion concerning the roles of older people, a "role-instrument" used by the interviewers to record the social roles of older people, an attitude inventory, and the Cavan Adjustment Rating Scale.

This, in the reviewer's opinion, is one of the best books published in the field in recent years.

WILLIS H. REALS
University College
Washington University

HOW TO RETIRE TO FLORIDA, by George and Jane Dusenbury, Third Revised Edition, Harper and Brothers Publishers, New York, 1954, 252 pages, including index, $2.75.

This constitutes a really good guidebook for those contemplating retirement. It presents a very rosy picture of life for the older person in Florida, and it is the kind of book that might have been prepared or publicized by the state or local Chambers of Commerce.

One might take exception to the author's statement that continuing to live after retirement in the same community "means a decline" and that the man who lives where he has worked becomes a "has been." Not a few who go into another community after retirement have been disillusioned, and have been glad to return to their old haunts, as did the retired English teacher who went to Florida and since he did not care for gossip, cards, shuffle board, or fishing, became weary, his blood pressure rose unduly, and he yearned for Missouri. On his return, he found the old place a pretty satisfactory one after all.

Much of the book is based on the replies to a questionnaire to hundreds of persons retired to Florida. Four chapters in Part Two (Choosing Your Section of Florida) discuss various places in the state for their suitability for retirement, their population, altitude, weather, living, and other conditions. Four chapters discuss health for older people in Florida, fishing, gardening, and interesting places to see.

Part Three is concerned with obtaining a home, moving arrangements, real estate, building, and life in trailer camps.

The very practical nature of the book is shown in the later chapters on how and what to move to Florida, a retirement budget, and successful case histories of those who have retired to Florida.

WILLIS H. REALS
University College
Washington University

THE NEEDS OF OLDER PEOPLE, and *Public Welfare Services to Meet Them*, by Elizabeth Wickenden, for the Committee on Aging, American Public Welfare Association, Chicago, 1953, 146 pages and Bibliography, paper bound $2.00.

The public welfare services are in the odd and paradoxical situation of being widely authorized and supported and equally widely misunderstood, or seen and understood only in terms of a specific failure. If only to correct and increase understanding of the subject, this small paper bound book is valuable. And it does its task with distinction. It carries no special pleading. It is not defensive. It has the "quiet, imperturbable confidence in the profession" that characterizes the well-rouunded physician's discussion of medicine, or the first-rate lawyer's view of the law as an institution. In short, it has a tone that should be recognizable to the readers of the Journal of Gerontology.

A quotation will illustrate the point of view from which the book is written: "The basic worth of each individual life and personality is the central value of public welfare. The marshalling of collective strength to support the individual, especially in his times of special vulnerability, is its particular assignment. This is done not to pamper weakness at the expense of strength but rather to permit each man to fulfill his own destiny and realize his own stature through a pooling of the strength of all." This is the common ground of all the helping professions.

Although public welfare is often thought to be money payments and nothing else, Miss Wickenden, with her committee, deals with that matter specifically in only 2 chapters out of 12 and goes on to show that non-financial service is equally important, to say the least. To name only a few—counsel, information, referral, employment, housing, dietetics, creative activity, recreation—the service being, of course, to help the individual solve his problems and continue on his own steam wherever possible. (By the bye, most social wokers will agree with Miss Wickenden that many of the public welfare services do not fit the old slots of "casework" or "group work," but a good many of these social workers will find it hard to accept the idea that public welfare stands "at the very

heart of the social work function. . ." partly because the profession has been unable to train enough people to staff the public services adequately. But this is an argument that has no place in this review.)

The size and the incidence of need of the older population make it inevitable that most physicians will deal with many patients who receive or need public welfare services. It is no secret that all is not smooth between physicians and welfare offices. This book could help put more understanding in the relationship on both sides. For one thing, it suggests to the physician what he should be able to expect from the welfare office staff; and if he isn't getting it, his knowledge of the lack will help bring about a correction, to the good of all concerned. The general statement of separate functions of physician and social worker (see pp. 79 ff.) and how they often dovetail sounds to this reviewer like a useful basic guide, give and take a little temperament on both sides of the team. (Since both physician and social worker accept temperament as a fact of life, this is no problem.)

The pages have a good many nubbins of concise common sense, and they should ring a bell in the life experience of most readers who have had no occasion to think on the questions before. For example, the brief discussion of what is called financial responsibility for relatives; another on administration of a lien law; or the way in which public welfare has come to stress the maintenance of independence—that is, many of our older ideas originated in work with children, who must for a time be dependent, but in work with adults, new methods and policies must be pointed toward avoiding dependency.

The study was made possible by a grant from the Doris Duke Foundation; and the auspices of the American Public Welfare Association came through a committee made up of public welfare administrators, private agency administrators, research technicians, and other citizens who have an interest in the problem. They have been well-served by this well-written study of how the public services meet the needs of older people: "Those human beings, who have used their years to the full and stand undefeated at the brink of the ultimate mystery, deserve better of society than condescending tolerance. They deserve respect, love, and—above all else—a firm place in our values."

LOUIS TOWLEY
George Warren Brown
School of Social Work
Washington University

BOOKS RECEIVED

Books received since November 1, 1953, are acknowledged in the following list.

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Care of the Aged in 1954, by Rose Kobak, Council of Jewish Federations and Welfare Funds, 165 West 46 Street, New York, 1953, 15 pages, multigraphed, unbound.

Entry and Reentry of the Older Woman into the Labor Market. I. Older Women in the Labor Force. II. Psychological Barriers to the Employment of Mature Women. From papers presented by Mary N. Hilton and Pearl C. Ravner at the Sixth Annual Conference on Aging, University of Michigan, Ann Arbor, 1953, reproduced with permission by U. S. Department of Labor, Women's Bureau, Washington 25, D. C., 20 pages, multigraphed, unbound.

How to Retire to Florida, by George and Jane Dusenbury, Harper & Brothers, New York, 1954, 252 pages, $2.75 (reviewed in this issue, page 232).

Needs of Older People and Public Welfare Services to Meet Them, by Elizabeth Wickenden, American Public Welfare Association, 1313 East 60 Street, Chicago, 1953, 146 pages, paper bound, $2.00 (reviewed in this issue, page 232).

Old Age and Retirement in Rural Connecticut. 2: Economic Security of Farm Operators and Farm Laborers, by Walter C. McKain, Jr., Elmer D. Baldwin, and Louis J. Ducoff, Bulletin 299, June, 1953, Storrs Agriculture Experiment Station, College of Agriculture, University of Connecticut, Storrs, 51 pages, paper bound.

Our Advancing Years, by Trevor Howell, Macmillan Company, New York, 1954, 192 pages, $3.50.

Pension Plans Under Collective Bargaining, Bulletin No. 1147, U. S. Department of Labor, Bureau of Labor Statistics, Washington, D. C., 23 pages, paper bound, 20¢.

Rehabilitation of Industrial Hand and Arm Disabilities, a series of papers presented at the Second Annual Conference and Demonstration for Compensation Insurers and Physicians, sponsored by the Institute for the Crippled and Disabled, 400 First Avenue, New York, 1953, 47 pages, offset printed, paper bound, $1.00.

INDEX TO CURRENT PERIODICAL LITERATURE

NATHAN W. SHOCK
Gerontology Section
National Heart Institute
National Institutes of Health

The subject categories are those in *A Classified Bibliography of Gerontology and Geriatrics* by Nathan W. Shock published by Stanford University Press, Stanford, California (1951). Only major headings are used and the Roman numerals correspond to those given in the bibliography. In so far as possible, references are classified according to organ systems. Thus most of the material on Geriatrics will be found under the organ system involved in the disease. Cross references are indicated by number at the end of each section. When available, abstract references are given *(B.A.—Biological Abstracts; P.A.—Psychological Abstracts;* and *P.I.—Population Index).* Abbreviations for journals are those used in *A World List of Scientific Periodicals Published in the years 1900-1933,* 2nd Edition. For journals not listed, abbreviations were devised according to the general rules used in the above source. It is impossible to cover all journals and list all papers concerned with aging and the aged. Authors and publishers are requested to call attention to publications or to send reprints to the Gerontology Section, Baltimore City Hospitals, Baltimore, Maryland. The assistance of the Forest Park Foundation, Peoria, Illinois, in the preparation of these materials is gratefully acknowledged.

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ORGAN SYSTEMS

I. Blood

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I-A. Blood: *Chemistry*

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(blood vessels, blood pressure, hypertension, blood volume, veins, and arteriosclerosis)

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III-G. Cardiovascular System: *Heart*

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V. Endocrine System

(includes sex glands and climacteric)

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VI. Gastro-Intestinal System

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VII. Kidney

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X. Nervous System

(neurology)

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XI. Reactions of the Body as a Whole

(allergy, anoxia, anesthesia, anthropometry, drugs, exercise, immunity, sleep, and temperature regulation)

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XII. Reproductive System

(ovaries, testis, see Endocrine System)

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